POST-QUAKE RECREATIONAL OPPORTUNITIES IN THE AVON RIVER AND THE AVON-HEATHCOTE ESTUARY/IHUTAI

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by Palamy Xayasenh

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Abstract

The Avon River and the Avon-Heathcote Estuary/Ihutai are features of the urban environment of Christchurch City and are popular for recreational and tourist activities. These include punting, rowing, organized yachting, water skiing, shoreline walking, bird watching, recreational fishing and aesthetic appreciation. The Canterbury earthquakes of 2010 and 2011 significantly affected the estuarine and river environments, affecting both the valued urban recreation resources and infrastructure.

The aim of the research is to evaluate recreational opportunities using a questionnaire, assess levels of public participation in recreation between winter 2014 and summer 2014-2015 and evaluate the quality of recreational resources. The objective is to determine the main factors influencing recreational uses before and after the February 2011 earthquake and to identify future options for promoting recreational activities. Resource evaluation includes water quality, wildlife values, habitats, riparian strip and the availability of facilities and infrastructure.

High levels of recreational participation usually occurred at locations that provided many facilities along with their suitability for family activities, scenic beauty, relaxation, amenities and their proximity to residences. Some locations included more land-based activities, while some included more water-based activities. There were greater opportunities for recreation in summer compared to winter. Activities that were negatively affected by the earthquake such as rowing, kayaking and sailing have resumed. But activities at some places may be limited due to the lack of proper tracks, jetty, public toilets and other facilities and infrastructure. Also, some locations had high levels of bacterial pollution, excessive growth of aquatic plants and a low number of amenity values. These problems need to be solved to facilitate recreational uses. In recovering

from the earthquake, the enhancement of recreation in the river and the Estuary will lead to a better quality of life and the improved well-being and psychological health of Christchurch residents. It was concluded that the Avon River and the Avon-Heathcote Estuary/Ihutai continue to provide various opportunities of recreation for users.

Chapter 1

Introduction

1.1 Background

Rivers and streams play a main role in supplying sources of drinking water, generating electricity, providing shelters for fish, waterfowl and other aquatic species as well as encouraging recreational and commercial uses. They also alleviate damage from floods, filter pollutants and recycle potentially harmful nutrients (United States Environmental Protection Agency, 2013). Many rivers flow from wider catchments into estuaries, which are influenced by human activities. Estuaries are coastal systems where ocean water, fresh water, land and atmosphere interact. These areas are complex, dynamic and biologically rich environments dominated by physical forces (Kemp et al., 2011). The estuaries of the Canterbury coastal zones offer diverse habitats for coastal species as well as potential for education, recreation and research (Marsden & Knox, 2008).

In the greater Christchurch region, there are rivers, streams, lakes, wetlands, estuaries and lagoons that can provide locations for sport and recreation activities including walking, cycling, swimming, boating, canoeing and fishing (Winterbourn, 2008). The Avon River and the Avon-Heathcote Estuary/Ihutai together with surrounding parks, reserves and wetlands are features of the urban environment of Christchurch City. They are popular for recreational and tourist activities and provide recreational playgrounds, educational resources for people to share their rich history, plentiful wildlife, beautiful scenery, and mahinga kai (food gathering) (McMurtrie & Kennedy, 2012).

Even though the Estuary provides easy access for visitors to interact with its environment, the health and biodiversity values of the Estuary have been impacted by urban

development. Storm water and associated contaminants such as heavy metals enter the Estuary from the wider catchment or through the city's main rivers, namely the Avon and Heathcote Rivers. Approximately 160,000 cubic meters per day of treated wastewater entered the Estuary between 1972 and 2010 and this has led to further contaminations and an excess of nutrients. These contaminants settle in the sediments and consequently affect the food chain once they are ingested by tiny invertebrates that are subsequently eaten by fish and birds (McMurtrie, 2011). As a consequence of this, health and mahinga kai values have been degraded (Pauling et al., 2007).

In order to protect the health of rivers and estuaries, Christchurch City Council (CCC) and Environment Canterbury have implemented "The Healthy Estuary and Rivers of the City: Water quality and ecosystem health monitoring programme of Ihutai". Environment Canterbury also undertakes the recreational water quality monitoring at sites in rivers and the estuary over the summer. Water monitoring is based on the Ministry of Health/Ministry for the Environment guides. The ANZECC (2000) water quality guideline provides a trigger value of water quality parameters. The New Zealand Microbiological Water Quality Guidelines for Marine and Freshwater Recreational Areas guideline provides a safe limit of 550 E.coli/mL in freshwater and 280 enterococci/mL in marine water. Freshwater containing less than 260 *E.coli* per 100 mL is acceptable for swimming (Ministry for the Environment, 2003).

The Canterbury earthquakes of 2010 and 2011 adversely affected historical, social and economic activities, buildings, infrastructure, vulnerable and valued resources, ecosystems and habitats (Canterbury Earthquake Recovery Authority, 2014). Business and residential areas in Christchurch and nearby towns were disrupted. Also, there was damage to local centers and community facilities (Canterbury Earthquake Recovery Authority, 2013). The earthquakes resulted in untreated human sewage being directly

discharged into several localities (Healthy Christchurch, 2011). It was estimated that more than 10,000 cubic meters of sewage was directly discharged into the Avon River each day for almost a year forcing closure of the Estuary to recreational activities. It reopened in November 2011 (Moriarty et al., 2013; T. Williams & Mackay, 2013). Environment Canterbury continues to monitor a range of sites after the earthquakes to track levels of bacterial contamination. These results have been used to advise the public of the potential health risk associated with recreational water activity sites and allow sites for recreational water use (Healthy Christchurch, 2011). Previously, primary sources of water quality degradation in the Avon River appeared to be related to wildfowl and possibly dog faecal material. Rainfall caused significant degradation of the microbial water quality of the Avon River due to those sources being washed into the river and as well as some low level human sewage inputs from the sewage system. The Avon River at Kerrs Reach and boatsheds at Antigua St have continued to have poor water quality in terms of public health risk. The average *E. coli* concentrations at these sites were close to the levels observed during direct sewage discharges, so contact with the Avon River water, sediments and estuarine sediments, particularly at Kerrs Reach, may continue to pose health risks to the public (Moriarty et al., 2013).

Another consequence of the earthquakes is related to critical changes to Canterbury's sport and recreation landscape (Sport Canterbury, 2011). Liquefaction volcanoes initially stippled the Estuary's floor. In addition, land lifting and subsidence have changed intertidal water level. A change to the water levels has resulted in the deepening of the channels (Measures et al., 2011). It is also reported that the earthquakes significantly affected both the valued urban recreation resources and the local recreation infrastructure (T. Williams & Mackay, 2013).

To recover from the earthquakes, Regional, District and City Councils have devised a number of recovery programmes and plans. CERA, Councils and regional sport organizations are taking responsibility to repair, protect and improve access to these recreational areas (Sport Canterbury, 2011). “Space, Places and People Plan for Sport and Recreation in Greater Christchurch” has been developed in cooperation with other key stakeholders to recover and enhance infrastructure for sport and recreation. The plan intends to support greater Christchurch having world-class locations that are accessible, encourage participation and attract tourism and major events for sport and recreation activities crucial to inhabitants (Sport and Recreation Earthquake Leadership Group, 2013). The improvement focuses on substantial areas and the physical infrastructure resources. Facilities such as toilets, access and paths can significantly impact the use of communal facilities such as parks. The absence or low quality of additional amenities and infrastructure can make people less likely to use those communal facilities, so facility planning should consider potential needs of user groups (Lee and Maheswaran, 2010 as cited in Looy, 2013).

While there has been a considerable amount of research on recreational activities, opportunities and resources in the Avon-Heathcote Estuary, little is known about the recreation values of the Avon River. These are needed to facilitate the restoration and enhancement of recreational uses of the river. The purpose of the Avon River (Central City) Master Plan is to guide the use and management of the river corridor for the next 25 years to protect, integrate and celebrate the many layers of natural and cultural heritage (Christchurch City Council, 2007). Recreational activities are also embraced into the improvement of life quality for residents (Architechs, 2009).

This master’s thesis research is focused on current recreational opportunities on the river and the Estuary by investigating recreational activities on the Avon River and the Avon-

Heathcote Estuary before and after the major earthquakes in 2010 and 2011. The earthquake recovery envisages a huge opportunity to reshape the delivery of sport and recreation (Sport and Recreation Earthquake Leadership Group, 2013) . Thus, it is also important to investigate recreationalist perceptions of the main factors influencing recreational uses and to identify future options for promoting recreational activities. The research aims to evaluate current recreational opportunities using a questionnaire, assess levels of public participation in recreational activities and evaluate the quality of recreational resources. The outcomes of this research will be useful for recreational planning in the Avon River and the Estuary. In addition, the river evaluation can be utilised by the Christchurch City Council to plan for recreation in the future as well as other baselines for future management.

1.2 Contribution of the Research in the Development of Water Management Systems in Laos

A large amount of research on recreational activities has been conducted in New Zealand whereas very few studies have been carried out in Laos. Undertaking a master's thesis research entitled "Post-quake recreational opportunities in the Avon River and the Avon-Heathcote Estuary/Ihutai" is an important opportunity to learn and understand the key principles of managing recreational uses that could be used in Laos.

Lao PDR has an abundance of natural resources including forests, water resources, biodiversity, agriculture lands and so forth. These resources provide a great potential for national socio-economic development and have supported livelihoods for their nations, multi-ethnic people for centuries (Ministry of Natural Resources and Environment, 2012). The management of water in Laos has an important role in starting and sustaining growth as well as in human development (Boualapha & Philavong, 2011).

The growth of population in cities, towns and villages has resulted in vast municipal waste and organic matter discharged into waterways. Generally, waste water in urban areas is inefficiently treated and disposed because most households rely on soak pits for wastewater disposal. Also, urban drains carry industrial discharges, septic tank leakage and overflow in the rainy season. Consequently, the mixing of sewerage in storm drainage systems often results in contamination with faecal matter and faecal coliform which will continue to pose risks to public health (Komany, 2010; Ministry of Natural Resources and Environment, 2012; Water Environment Partnership in Asia, 2010).

In rainy and dry seasons, surface water quality in both urban and rural areas is sometimes poor and this has affected aquatic resources, aquatic species and their habitats. Rivers and perennial streams are crucial sources of fish and other aquatic products as they sustain a range of aquatic organisms throughout the year. Also, the aquatic environment has not been well studied (Ministry of Natural Resources and Environment, 2012).

Even if water resource development has contributed to economic growth, there is still a great need for the development of institutional frameworks and the social and technical capacity to implement development strategies. Additionally, the limited availability of information and the short history of water governance are constraints to water planning in Laos. This has resulted in difficulties in reaching the required consensus, involving relevant stakeholders, defining a set of measures, selecting projects and implementing and monitoring them (Boualapha & Philavong, 2011).

The main policy and legislation on water quality is the Law on Environmental Protection (LEP) (adopted in 1999) and related legislation. There is the Law on Water and Water Resources. The Ministry of Health in collaboration with WHO/UNICEF has developed Drinking Water Quality Guidelines (2005) (Komany, 2010). The government of Laos has adopted the National Environmental Management Strategy to 2020, Environmental

Education and Awareness Strategy to 2020, National Biodiversity Conservation Strategy to 2020 and the National Water Resources Policy and the Strategy and Action Plan. Protection of water quality and natural health, management of water resource risks, awareness, data collection and analysis are among objectives of the National Water Resources Policy and the Strategy and Action Plan (Boualapha & Philavong, 2011). However, there is no legislation governing the use of water for inland navigation (Kundell, 2007). Moreover, no water monitoring program and no guidelines for contact recreation have been regulated.

The experience gained working within a sound water management system will be highly beneficial for future research in Laos. New Zealand was selected as a case study as Laos lacks information on recreational uses and values. Conducting this research will strengthen understanding of the management of water and recreation in order to develop strategic, material and technical skills that can be applied to planning design and operation of projects and facilities. It can enhance knowledge on the governance and institutional frameworks underpinning water resource management. Also, the researcher gains knowledge of analytical techniques and tools for water management as well as understanding the principles of managing recreational uses. These skills can be applied to projects involving evaluating aquatic habitats and monitoring water quality in order to develop recreational uses in Laos. The methods used in this research can be used in similar studies in Laos to provide relevant information for the Lao policy makers to support the implementation and decision making in conserving and improving its natural resources. More recreation-related studies in Laos will help recognizing the importance of healthy recreation and raising awareness of health risks deriving from contact recreation.

1.3 Research Aims and Objectives

There are three parts of this study. The aim of the research is to evaluate current recreational opportunities using a questionnaire, assess levels of public participation in recreational activities and evaluate the quality of recreational resources in the Avon River and the Avon-Heathcote Estuary/Ihutai.

The specific objectives are:

- To evaluate recreational opportunities of the river and the Estuary including characteristics of activity patterns, spaces and places for undertaking various recreational activities.
- To identify what recreational activities were undertaken by recreationists before and after the February 22nd earthquake and which of those activities have been influenced most by the earthquake.
- To investigate recreationalist perceptions on the main factors influencing their recreational uses, water quality and health risks.
- To compare public participation in each type of recreational activities in the winter 2014 and summer 2014-2015.
- To evaluate the quality of recreational resources at 5 locations based on values including water quality, the presence of wildlife, habitats and riparian strip along the river banks and shores of the Estuary, the availability of recreational facilities and infrastructure within area (e.g. 400 m^2) at each study site.
- Using the results from the study, identify future options for promoting recreational activities, opportunities and resources at the Avon River and the Avon-Heathcote Estuary.

1.4 Study Locations

Five locations were selected for this study, three along the Avon River included the Botanic Gardens, Antigua Boatsheds and Kerrs Reach and two at the Estuary were Pleasant Point Jetty and Moncks Bay (Figure 1.1). More river locations were chosen because many locations at the Estuary had been studied previously. These locations represented different physical characteristics and recreational pursuits in the Avon River and the Estuary. An area of 1 km^2 at each study site was initially proposed for assessing recreational resources, but it was found that the area was too large because some study areas were too close together. The area used to evaluate recreational resources at each study site was narrowed down to 400 m^2 (Appendix 1).

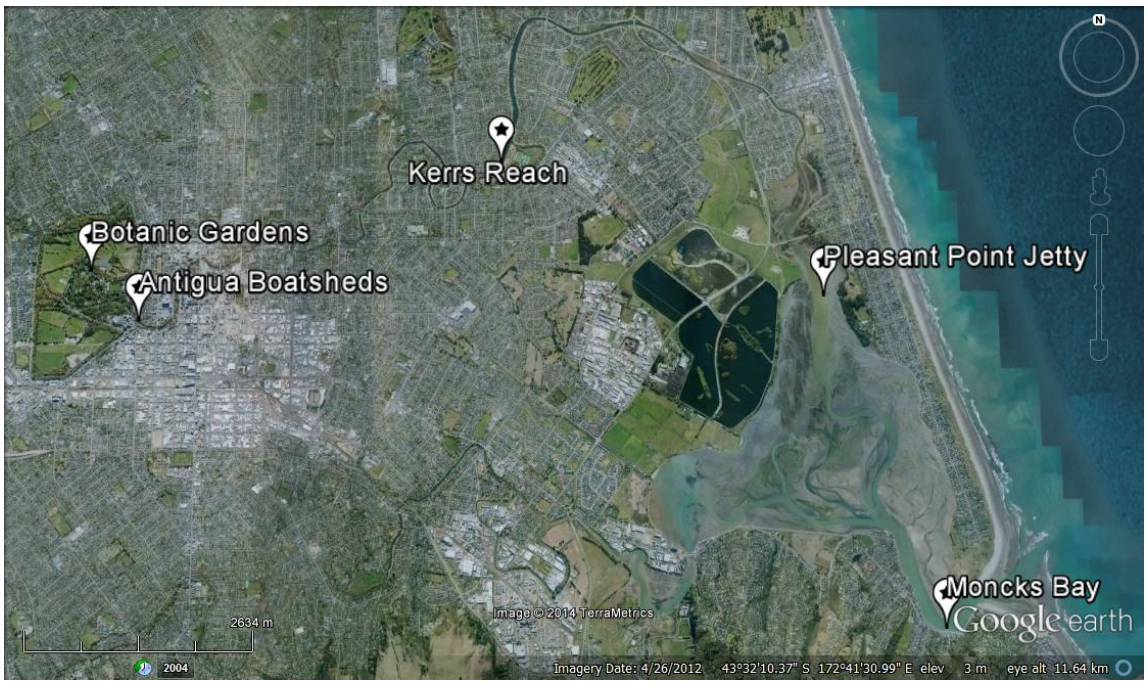


Figure 1.1 Map of study locations.

1.5 Structure of Thesis

The thesis comprises five chapters. This chapter one covers background of the study, contribution of the research in the development of water management systems in Laos,

research aims and objectives, location selection and thesis structure. The three major parts of the study are presented in chapters two, three and four involving evaluation of current recreational opportunities, assessment of levels of public participation in recreational activities and evaluation of the quality of recreational resources respectively. Each chapter consists of the introduction with a literature review, methods, results and discussion. The last chapter discusses the results of the thesis research and implications of the research on management.

Chapter 2

Evaluation of Current Recreational Opportunities

2.1 Introduction

2.1.1 The Avon River/Ōtākaro and the Avon-Heathcote Estuary/Ihutai

There are two rivers meandering into the Estuary namely the Avon River/Ōtākaro and the Heathcote River/Ōpāwaho. These rivers are spring-fed and slow-flowing. They both have several tributaries involving natural streams and artificial drains. Because they flow via residential, commercial and industrial areas of the city, they usually transport nutrients, sediments and pollution to the Avon-Heathcote Estuary/Ihutai (Environmental Services, 1993 as cited in Dodson, 2007).

The Avon River is an important landscape feature of Christchurch's centre (Pryor, 1984). The river has a length of 26 km and it originates from Avonhead located at the western part of Christchurch City. The river is impacted by tides up to the Barbadoes Street Bridge and there is mixing of saline and fresh water as far as Wainoni Road Bridge up the river (Environmental Services, 1993 as cited in Dodson, 2007). The meandering river contrasts with the linear grid of city streets and can provide a great value to the psychological needs of people living in the city (Pryor, 1984).

The Estuary is the largest, semi-enclosed, shallow estuary in Canterbury, but its area of 700 hectares is relatively small on a global scale (McMurtrie & Kennedy, 2012). It has long been a social hub for Maori and Europeans who live in close proximity (Boyd, 2010). The Estuary has significantly different habitats which support a wide variety of species such as fish, birds, invertebrates and plants (McMurtrie & Kennedy, 2012). In the Avon River and Avon-Heathcote Estuary, sheltered waters are not only home to

countless birds and animals, but they have also contributed greatly to the lifestyles of people for hundreds of years (Jones, et al., 2005).

2.1.2 Recreational Use of the Avon River and the Estuary

From the early settlement of Maori until present, the Avon River and the Avon-Heathcote Estuary have held great significance for the people of Christchurch because of their abundant resources. They mainly provided early Maori with sources of mahinga kai (food gathering) (Boyd, 2010). After the arrival of Europeans, the river and the Estuary were developed as main transport routes as well as areas for a wide range of recreational activities. Subsequently, the Estuary became more polluted from the late 19th century and early 20th century because the Avon and Heathcote Rivers were used for disposal of waste from industrial areas and factories, and the Estuary was subsequently used for sewage and waste water discharge by mid-20th century (Boyd, 2010). The area was slightly improved after the Bromley Waste Water Treatment Plant was built. From the 1960s, initiatives in trying to enhance the water quality, conservation and recreational values of the Estuary were carried out. Consequently, the Estuary became one of the most important wetlands of New Zealand because it provided shelter for several migratory birds (Boyd, 2010). According to Crawford and Fountain (2010), this notion was still valued by regular Estuary visitors (over 75%), and the Estuary has been considered as a great recreational resource for Christchurch inhabitants.

The Avon River was the only source of water supply for the early settlers. In later years, the river and its banks have supported a wide range of recreational uses such as rowing, enjoying the view and relaxing by its surrounding (Weiss, 1984). Corboy (1985) asserted that if the river were not part of its surrounding, several recreational areas and locations along the river would be worthless.

In 1979, McKenna studied a recreational geography of the Estuary. The finding showed that the Estuary provided Christchurch inhabitants with a wide variety of water and land-based recreation opportunities. The natural environment at the Estuary and its surrounding areas supported activities including trail bike riding, walking, bird watching, collecting shellfish, family recreation, picnicking, watching recreation, sunbathing, painting and sketching, horse riding and strolling.

Greenaway (2007) carried out research to help identify the recreational values of the Avon-Heathcote Estuary and the built and natural resources which support those activities, with access being of particular interest. The results showed that walking, dog walking, cycling, wind/kite surfing and sailing are main recreational activities at the Estuary. Beautiful scenery and views were regarded as the most important features of the Estuary, followed by proximity to their home. Further finding was that some respondents (54%) had been dissatisfied with their experience at the Estuary mainly due to rubbish and litter, poor water quality and so forth. Crawford and Fountain (2010) noted the value of the Estuary being deteriorated by water pollution as well. Suggestions for potential improvement of the Estuary made by some respondents were enhancing water quality and removing rubbish, litter and graffiti (Greenaway, 2007).

Recently related research by Crawford and Fountain (2010) investigated the usage, awareness and perceptions of tourism and recreational opportunities of the Avon-Heathcote Estuary. People mostly visited the Estuary for exercise or walking a dog, followed by taking children for various activities (e.g. playing at the playground or playing games with them), whereas seafood gathering or fishing were undertaken by very few Estuary visitors due to being concerned about health risks. Almost 40% of Estuary users visited daily and around 23% visited weekly. Estuary visitors usually

walked or drove to the location (Crawford & Fountain, 2010). The Estuary Walkway, the Spit and South New Brighton Park were venues that were most popular for recreation at the Estuary (Crawford & Fountain, 2010).

Crawford and Fountain (2010) found that a large number of non-visitors to the Estuary lacked knowledge about what was available at the Estuary, so it was suggested to provide information about the availability of activities and facilities. Recently, McMurtrie and Kennedy (2012) designed a field guide to introduce recreational users to the abundant wildlife, locations of historical interest, and favored recreation locations of the Estuary. This guide is not only beneficial for non-visitors, but it is also relevant to Christchurch residents. Many places around the Estuary have been identified as suitable for different recreational uses with features and amenities such as walkway or tracks, toilets, wildlife areas, bird-watching locations, lookout points, earthquake damage and human history locations, water sport areas, and stroller friendly and walking only areas (McMurtrie & Kennedy, 2012).

T. Williams and Mackay (2013) carried out a study to investigate the effects of the earthquakes on recreation opportunities and facilities located at the northern reaches of the Estuary. It was found out that a lot of urban recreation resources and the local recreation infrastructures were significantly affected by the Canterbury Earthquakes of 2010 and 2011. Furthermore, Marquet and Duncan (2012) reported that land-based participants expressed views about unusable footpaths and walkways, unstable tress, smelly areas and closed Estuary as the result of the earthquake.

It was noted that the earthquake has brought about issues and challenges, but the community positively envision a range of opportunities for recreation at the Estuary in the future (T. Williams & Mackay, 2013). The community has encouraged events,

workshops, community consultations, integrated approaches, policies and practices to attract family and recreationists back to the Estuary. The community has a real sense of place, place attachment and place ownership. T. Williams and Mackay (2013) concluded that it is most challenging for the community and local authorities to maintain the fine balance between allowing the natural environment to be restored and improved and establishing new recreational spaces and places that revive the socio-economic value of the area.

2.1.3 Perceptions of Water Quality

Previous studies on perceptions of water quality were carried out in many countries in order to support management and conservation of water, public awareness on water uses and the development of water policies. Perceptions of water quality were delineated in terms of aesthetic values such as odours, colour of the water, cleanliness and other key visible factors like debris (Patrap, 2011). In similar research by Nare et al. (2006), it was noted that physical characteristics of water quality were often a concern of residents in the Mzingwane catchment in Zimbabwe. Studies by other researchers also presented similar results (Dodson, 2007; M. A. House, 1996; Jensen & McLellan, 2005; Nicolson & Mace Jr, 1975).

Additionally, Happs (1986), examined how members of the New Zealand public perceived water appearance and quality, and concluded that people tended to perceive the quality of water through visual and olfactory (smell) observations more than paying attention to measurable factor like levels of bacteria. Likewise, Smith and Davies-Colley (1992) looked at the perception of water quality, colour and clarity in terms of suitability for recreational use. The results showed that the colour and clarity of water can

significantly affect water use for recreation. He also added that it was complex to understand water quality through public perceptions and attitudes.

Further findings were that perceptions of water quality were associated with spatial patterns (Brody et al., 2005). Various social and location factors have contributed to the formation of hot spots of spatially environmental perceptions. People were likely to have similar environmental views and values to those living close to them (Brody et al., 2005). Kerr and Swaffield (2012), who undertook a study to identify cultural service values of small river of Canterbury in New Zealand, found that whether stakeholders were farmers, recreationists, conservationists or not, people agreed that pure, clear water, continuity of flows and well-managed riparian vegetation are important stream attributes (Kerr & Swaffield, 2012).

In order to appreciate water quality issues, it was imperative for people to obtain more information (Cochrane et al., 2011; Slovic, 1987). Dodson (2007) conducted research to investigate whether or not perceptions of river users of the Avon and Heathcote Rivers match the reality of the rivers as determined through scientific monitoring. The results indicated that perceptions of river users differed from the reality of the rivers. For instance, the public were aware of the health risks of poor water quality, but a great number of river users were unaware of causes of the risks, the key sources of pollution and changes of water quality, and the ecological health of the rivers impacted by land use activities. Thus, the recommendation made for research in the future was to examine ways to implement public education systems.

Another social research project undertaken by Marquet and Duncan (2012) was to gain insight into what factors influenced decisions of recreationists to undertake recreational activity in the Estuary, and the extent to which quality information provided by the

Regional Council and the City Council was utilized. In contrast with a study by Dodson (2007), it was found that microbiological water pollution was recognized by recreationists. Perceptions of water quality risks and decisions on participating in recreational activities of respondents were impacted by affective factors (e.g. experience, feelings, visual and olfactory observations), social factors (e.g. trust of officials, media, anecdotal evidence) as well as cognitive analysis of scientific information (e.g. costs and benefit weighing up of risk characteristics and the assessment of monitoring measurements) which were mainly obtained from the local councils and recreational clubs. In comparing the results from the two studies, the random respondents selected in Dodson's study were general river users, whereas the respondents from Marquet and Duncan's study were certain user groups such as recreational club members. It appeared that people who visited the area frequently tended to correctly identify the main forms of pollution (Faulkner et al., 2001).

Patrap (2011) studied how the public and recreational water users in particular appreciated and utilized water quality information. The research found that it was vital to link the information to sources that were already used and accessible such as weather report, on television, on the radio, online or in newspapers. Aakko (2004, p.25) argued that it was easier for risk communication to be dispersed than risk information. Although one-way communication was usually applied in awareness raising methods, meaningful two-way communication was a means that tended to gain insight into what information is actually most beneficial for those who use it as well as what is and is not working (e.g. signs were poorly erected, not visible, not updated and unclear) (Patrap, 2011).

In addition to scientific information, Aakko (2004) stated that meaningful communication assisted in informed decision-making because risk communication

involved building trust from an interactive and ongoing communication process in which audience members are active participants. Aakko (2004) added that meaningful communication can assist in diminishing unwarranted fear, anxiety and distrust. Also, effective risk communication can help reduce health risks (Fischhoff et al., 1993).

A number of factors affecting risk perceptions have been identified in several studies. These involved beliefs, attitudes, judgments and feelings (Royal Society, 1992 as cited in R. Harding et al. 2009); personal characteristics (Barnett & Breakwell, 2001; Powell, 2007); psychological and institutional factors (R. Harding et al., 2009; Powell, 2007); probability (Botterill & Mazur, 2004); experience (Barnett & Breakwell, 2001; Botterill & Mazur, 2004; Creyer et al., 2003; Powell, 2007).

According to Canter et al. (1992), a wide range of factors influencing public perceptions of water quality risks identified involved age, education level, personal usage of water, history, visibility of pollution, proximity, familiarity with contaminants and sources, trust of local public officials, involvement in decision processes and the level of risk communication efforts. Other factors linking to health risk decisions were feelings and emotions (Fischhoff et al., 1993). Besides, a conceptual model was developed by Menon et al. (2006) to identify five classifications of antecedents that feed into health risk perceptions. These included individual differences, motivations, and affective, cognitive and contextual factors.

The media has played a role in promoting water quality perceptions. It was evident that media reports, anecdotes and personal bias were engaged in many responses with prior knowledge (Happs, 1986). Also, Pendleton et al. (2001) stated that the media had more influence on perceptions of coastal water quality than coastal education campaigns. Likewise, Patrap (2011) reported that the internet was the source used the most for

acquiring water quality information, and television, newspapers, radio, newsletters or brochures being commonly used among members of organized groups and vendors.

Nare et al. (2006) conducted research on stakeholder participation in water quality management in the Mzingwane catchment in Zimbabwe. The result revealed that it was crucial to integrate local knowledge with the standard monitoring systems and supplement standard monitoring data in order to gain involvement of communities in water quality management decisions.

2.2 Methods

2.2.1 Questionnaire Design

The questionnaire design essentially involved the questionnaire aims, a definition of the target population, the sample size, time frames and sufficient literature on previous surveys (Dorofeev & Grant, 2006). A questionnaire was designed for use at each study location in winter 2014 and summer 2014-2015. Questions sought to evaluate recreational opportunities in the river and the Estuary; to investigate recreationalist perceptions on the main factors influencing recreational uses, water quality and health risks; to identify which recreational activities have been influenced most by the February 22nd earthquake; and to identify future options for promoting recreational activities. The questionnaire comprised both qualitative and quantitative questions (Appendix 2).

From a literature review of similar questionnaire surveys, it became evident that research on recreation using onsite interviews usually gained greater participation than online or telephone surveys. For example, recreational studies undertaken by Dodson (2007), Lizamore and Montgomery (2010), McKenna (1979) received adequate responses by conducting surveys at study locations with time period used between 5-30 minutes to

complete questionnaires. Additionally, Crawford and Fountain (2010) carried out onsite and telephone surveys and noted that a response rate for the onsite surveys was much higher, with most people willing to participate. Furthermore, face-to-face interview is a technique that usually produces a high response rate and credible survey results (Fink & Kosecoff, 1985; Frey & Oishi, 1995). Onsite questionnaires, therefore, were selected for this study and were conducted by the researcher because this would ensure some control over consistency in response and sampling procedures (Frey & Oishi, 1995; Oppenheim, 1992). Open-ended questions were used to obtain a wide range of participants' views, opinions and attitudes (Fabrigar & Ebel-Lam, 2007).

2.2.2 Questionnaire Distribution

Pilot observations were undertaken two weeks before the questionnaire in winter was carried out. Considering daylight hours, sampling was stratified by the time of day involving 8 am–11 am, 11 am-2 pm and 2 pm–5 pm in order to include information from people who might undertake different activity at the locations. For instance, rowers at Kerrs Reach usually practiced after school. Sailors and stand up paddle boarders at Moncks Bay performed the activities at high tides. Additionally, a few locations with limited access points provided the ease for getting participation. The other locations are accessible from different directions, both sides along the Avon River, and many access points along the Estuary Walkway at Moncks Bay. Onsite questionnaires, therefore, were carried out at areas where more people were observed performing recreational activities within study locations.

2.2.3 Preliminarily Investigation of Questionnaire

The study aimed to obtain information from 50 participants in winter, 10 from each location, and 100 participants in summer, 20 from each location. Participants were people who used the Avon River and the Avon-Heathcote Estuary/Ihutai for recreation within an area from Mona Vale, in the City to Scarborough, at the mouth of the Estuary. Participants included Christchurch residents and tourists who visited a selected location on a particular day.

The questionnaire in winter was launched from mid July 2014 until the end of August 2014. At each study location, the questionnaire was conducted three times with the aim to include three to four participants at each time. Initially, people in study locations were asked at random to voluntarily participate in the study. The questions were asked verbally allowing the researcher to elaborate questions not understood and produce more detailed and precise answers for open-ended questions (Frey & Oishi, 1995; Oppenheim, 1992).

By the end of August 2014, the questionnaire in winter was completed by 44 participants at five locations. The research methodology was reviewed. We found that it was difficult to get participation from certain groups, rowers at Kerrs Reach, sailors and stand up paddle boarders at Moncks Bay.

After the questionnaire in winter was finished, the information obtained was subsequently analysed in a draft, and the questionnaire was revised. There were a few questions modified because it seemed many people did not respond thoughtfully.

2.2.4 Refining of Questionnaire Methods

To complete the questionnaire in summer, the sampling procedure was changed. In addition to getting participants from the locations, we considered that it would be preferable to approach these recreational groups (rowing clubs, sailing clubs and stand up paddle boarding groups) to assist in the research. Thus, we made two types of questionnaire – one was to be used for completing at the locations, and the other was to be used for those participants filling out the forms electronically (Appendix 2). The application to the Human Ethics Committee was revised to include participants who may fill out the forms electronically.

A week before conducting onsite interviews in summer in mid November 2014, a contact letter was sent via emails to target recreational groups asking if they would be willing to help in getting participants in the survey (Appendix 3). An electronic copy of the questionnaire, an information sheet and consent form were also attached to the emails (Appendix 4). A few rowing clubs and Christchurch Yacht Club acknowledged that they would assist in the study by either forwarding the email to their group emails or posting the questionnaire on their Facebook pages. Eight recreational users from these clubs completed the questionnaires electronically. Even though no responses were gained from stand up paddle boarding groups, onsite surveys at Monck Bay were accomplished by an adequate number of participants.

The questionnaire closure in summer was proposed on 4th January 2015, but Kerrs Reach appeared to get less participation from recreationists than expected. Thus, another week was extended to get more participants from this location, and the questionnaire in summer was eventually finished on 11th January 2015 with enough participants from all study locations.

2.2.5 Data Analysis

Initially, data gathered from interviews was compared in order to determine whether age groups of participants were identical in both questionnaires. A chi-square test (Appendix 5) showed that there was no statistically significant difference between age groups, but there were seasonal difference. Results were analysed separately for some questions by chi-square goodness of fit and test of independence. These tests were used to compare seasonal difference in recreational activities and to investigate location-related differences. Microsoft Excel was used as a primary data management tool for editing, coding, data entry and creating charts from the raw data from all field activities including the survey. Another statistical analysis involved Nvivo that was used to analyse open-ended questions.

2.3 Results

The questionnaires were completed by 144 participants in total and generated a high response rate of 96 percent. It was observed that some missing details and errors were derived from the process of recording and summarizing a long and rambling response. This similar problem was identified in the study by McKenna (1979). Also, it was anticipated that time had influenced interviews from a few participants not providing open-ended responses. However, the qualitative data acquired was satisfactory to bring about efficient investigation on recreational opportunities of the river and the Estuary.

2.3.1 Participant Demographics

Of all participants interviewed, the most significant age group for both male and female was 41-60, closely followed by 26-40 (Figure 2.1). The proportion of male participants was greater than female participants that was 56% and 44% respectively.

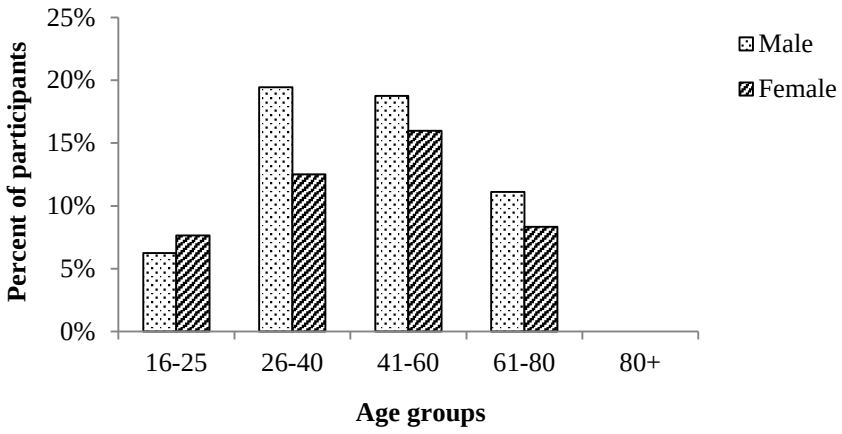


Figure 2.1 Distribution of age groups of participants.

The majority of the participants were Christchurch residents, which accounted for 89 %, whereas the participation of oversea tourists was only 7% (Table 2.1).

Table 2.1 Place of residence of participants.

Place of residence	Frequency	Percent
Christchurch resident	128	89
Domestic tourist	6	4
Oversea tourist	10	7

2.3.2 Recreation Characteristics and Habits

Group Participation

Participants were asked if they were accompanied by others when they performed recreational activities. From Figure 2.2, it illustrates that over half (87) of the participants undertook the activities by themselves. Some participants were also accompanied by family members and friends. Only 17 participants said “other” including recreational clubs, colleagues and their partners. An individual might performed more than one activity, so different activities might be undertaken with different recreational users.

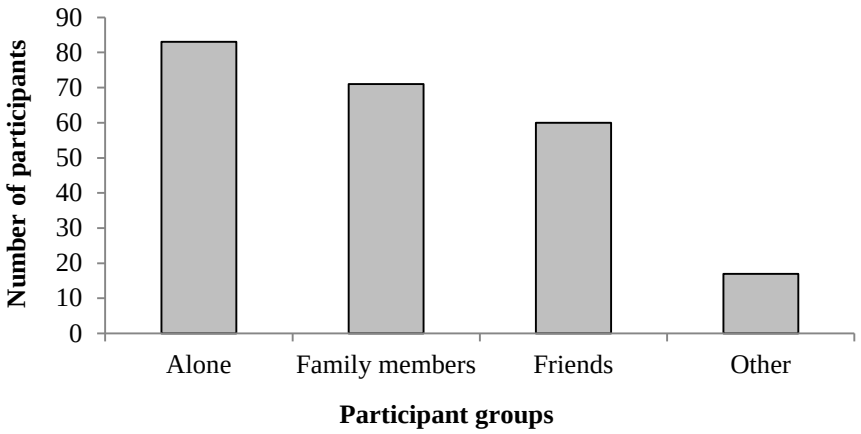


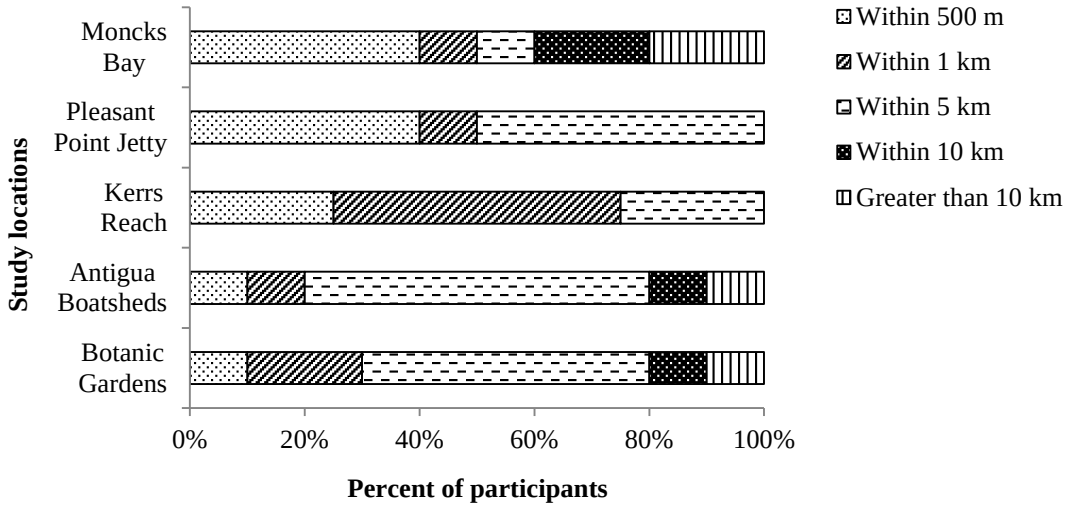
Figure 2.2 Groupings undertaking recreational activities.

Travelling Distance and Travelling Modes

At each study location, people travelled different distances from their residential places. Chi-square tests were used to examine seasonal difference between locations (Appendix 5). Some results indicated that distance travelled by participants in winter substantially differed from those in summer, especially, at Kerrs Reach, Pleasant Point Jetty and Mocks Bay. As shown in Figure 2.3a and 2.3b, a high percentage (50%) of participants travelled less than 1 km to Kerrs Reach in winter, while 40% of participants travelled distances up to 5 km in summer. It is also interesting to note that the number of participants dwelling within 500 m of Moncks Bay and Pleasant Point Jetty were the main group using the venue for recreation in winter, which made up 40% each, whereas the major participants (approximately 50%) recreating at these locations were those living within 5 km in summer.

In contrast, the travelling distance to participate in recreational activities at the Botanic Gardens and Antigua Boatsheds were similar in both seasons. For instance, more than 50% of participants travelled by 5 km from their residential places for recreation at both locations at the Avon River (Figure 2.3a & 2.3b).

2.3a



2.3b

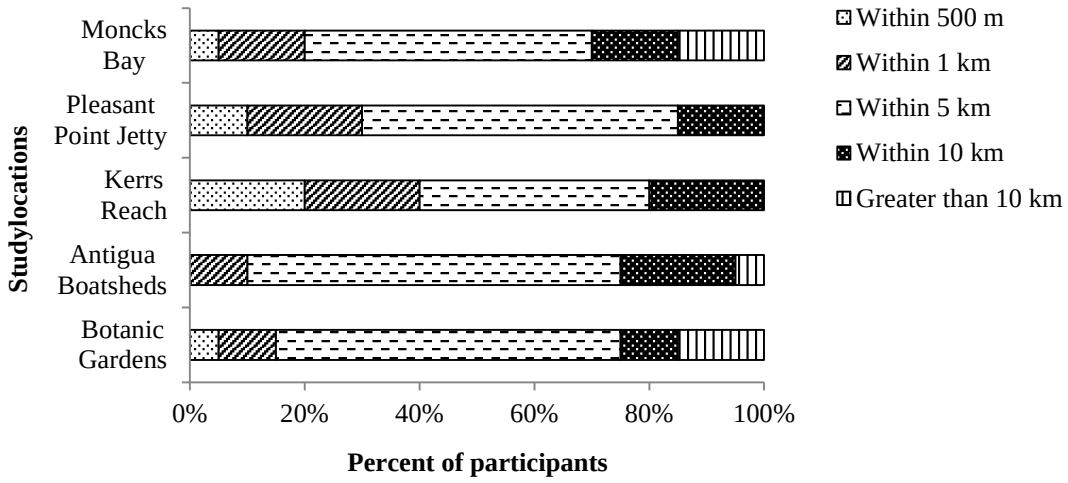


Figure 2.3 Travelling distance from residential places to study locations in winter (a) and summer (b).

Although several areas within the river and the Estuary are used for recreation, participants at all study locations regularly carried out activities in nearby places. These places were in close proximity to their home (less than 5 km). For example, some of those who undertook activities at the Botanic Gardens also visited Antigua Boatsheds or Hagley Park. Some participants at Pleasant Point Jetty recreated at South New Bright Park, South New Brighton Walkway as well.

Table 2.2 presents information on travelling modes utilized by participants who lived further than 500 m from each study location. Participants living within 5 km and travelling by car made up the greatest percentage of 35%. Participants mainly walked to the locations within 5 km, which comprised of around 20%. Less than 1 % of participants lived greater than 10 km and travelled to the locations by a bike. Other travelling modes used by participants included running, bike skating, skateboarding.

Table 2.2 Influence of travelling distance on travelling modes.

Distance	**Travelling mode (%)**				
	Walking	Cycling	By a car	By a bus	Other
Within 1 km	12.50	2.08	0.69	0	0
Within 5 km	7.64	0.69	34.72	0.69	6.25
Within 10 km	0	3.47	10.42	0	0
Greater than 10 km	0	0.69	6.94	0	0

Seasonal Patterns of Recreational Activities within the River and the Estuary

In general, 113 participants visited the locations for recreation all year round compared to those who merely undertook recreational activities at the river and the Estuary in summer (25) and winter (6).

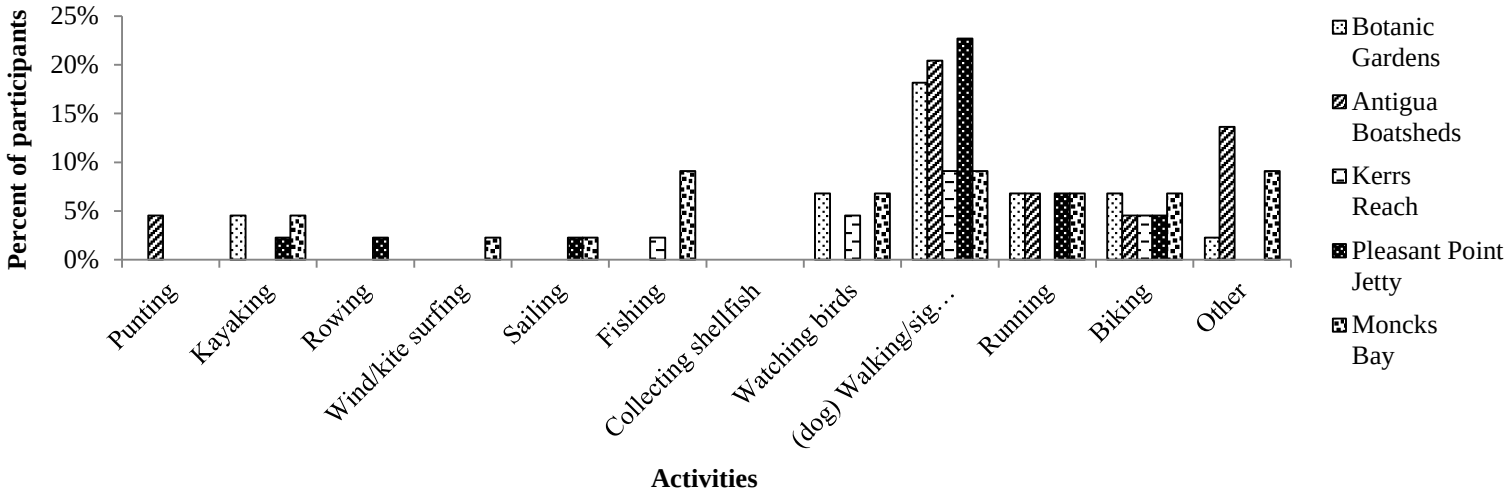
In order to investigate characteristics of activity patterns, the number of samples in winter and summer was fixed to the same proportion. Results from chi-square tests (Appendix 5) displayed that season has impacted activity patterns at some locations. For instance, greater percentage (more than 18%) of (dog) walking/sightseeing was observed in winter than in summer at the Botanic Gardens. Also, participation in (dog) walking/sightseeing (more than 20%) and running (approximately 7%) were higher in winter compared to summer at Antigua Boatsheds and Pleasant Point Jetty (Figure 2.4a & 2.4b). None of the participants undertook kayaking at Antigua Boatsheds and Kerrs

Reach in winter, but these activities took places in summer. Also, 8% of participation in rowing were merely presented at Kerrs Reach in summer.

Mocks Bay, however, was the only location that activity patterns were not influenced by season. Participation in fishing, watching birds and (dog) walking/sightseeing in both seasons was greater than other types of recreation.

Participation in other activities included having picnic, playing at playgrounds, skate boarding, jet skiing, standup paddle boarding, boating, canoeing, feeding/watching ducks and passive recreation such as meeting friends, reading, sitting, having lunch, viewing the environment and watching activities. Relatively high percentage of participation in feeding/watching ducks and passive recreation was observed at the Botanic Gardens and Antigua Boatsheds. Participation in these activities in summer at the Botanic Gardens appeared to be higher than in winter.

2.4a



2.4b

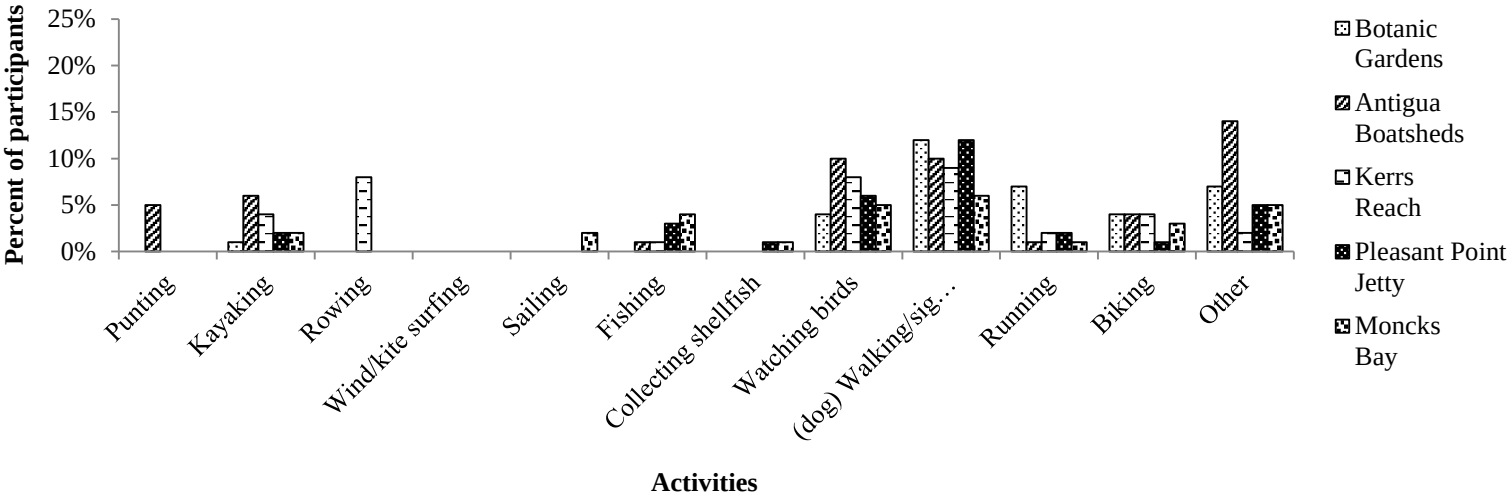
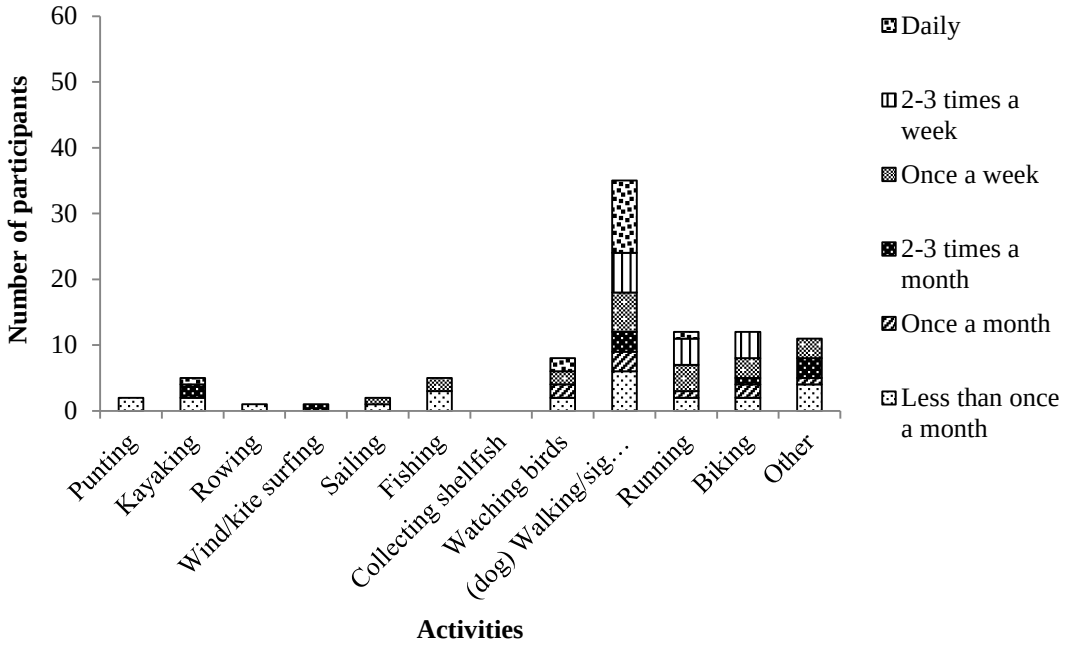


Figure 2.4 Type of recreational activities undertaken by participants in winter (a) and summer (b).

Frequency of Undertaking Recreational Activities

The frequency of participation in some activities might alter between seasons. From chi-square calculations (Appendix 5), the frequency of fishing, watching birds, (dog) walking/sightseeing, running and other activities in summer was higher than winter. For example, (dog) walking/sightseeing daily or 2-3 times a week was observed more in summer as well as watching birds and running (Figure 2.5a & 2.5b). Also, some participants went fishing more frequently in summer (e.g. 2-3 times a month).

2.5a



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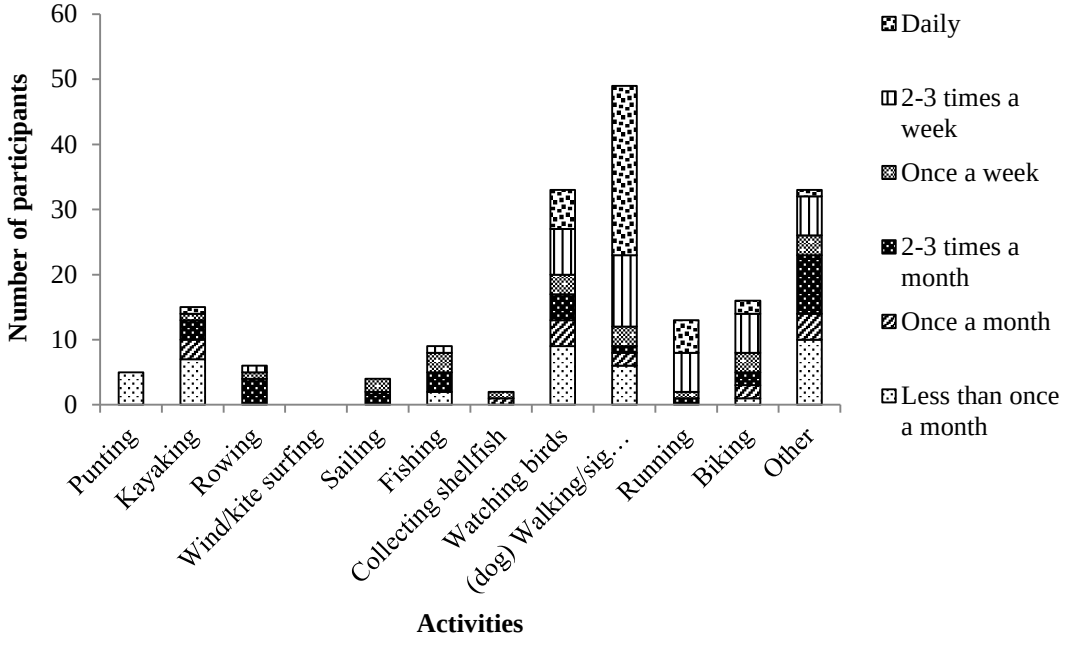


Figure 2.5 Frequency of undertaking recreational activities in winter (a) and summer (b).

2.3.3 The Impacts of the Earthquakes on Recreational Users

Participants were asked if the earthquake interfered with their recreational activities compared with one year before the 22nd February earthquake. More than half (64%) of participants responded, with 73% reporting that their recreation had been affected by the earthquake, while 27% mentioned that the earthquake did not affect their activities (Figure 2.6a & 2.6b).

Disturbance to recreational activities was generally attributed to closure of the estuary, inaccessible areas along the river, polluted water and construction along the river and roads. Other interference with activities involved damaged equipment and buildings, house repairs, motivation to do activities, pressure of works and dangers from erosion and uneven tracks.

2.6a **2.6b**

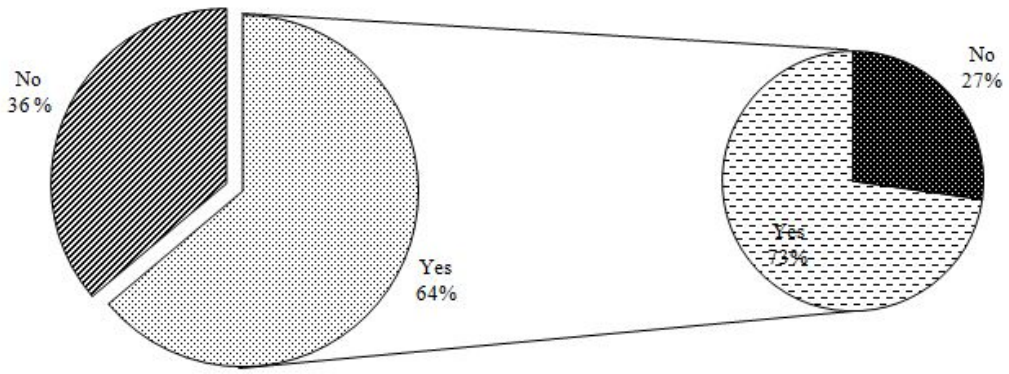


Figure 2.6 Participation in recreational activities before the 22nd Febuary earthquke (a) and Participant's activities impacted by the earthquake (b).

Overall, there were few changes in recreational participation due to the earthquake (Figure 2.7). Participants ceased certain activities post earthquake during the Estuary closure in 2011 and some recreation on river locations also stopped for some time. This

resulted in recreational users visiting alternative venues for recreation such as nearby parks, New Brighton and beaches. However, the earthquke forced rowers from Kerrs Reach to traval a further distance to row on the Waimakariri River from Kaiapoi for a year because at Kerrs Reach, boats, equipment and buildings were mostly destroyed and the water was heavily polluted. When water quality had improved and club resources were relocated and checked for safety, rowers resumed in the Avon River again. It is also interesting to note that participation in other actitivies showed a greater increase compared to punting, kayaking and watching birds. In summary, the earthquake affected most activities at first, but most participants were able to return to use the river and the Estuary for recreation (Figure 2.7).

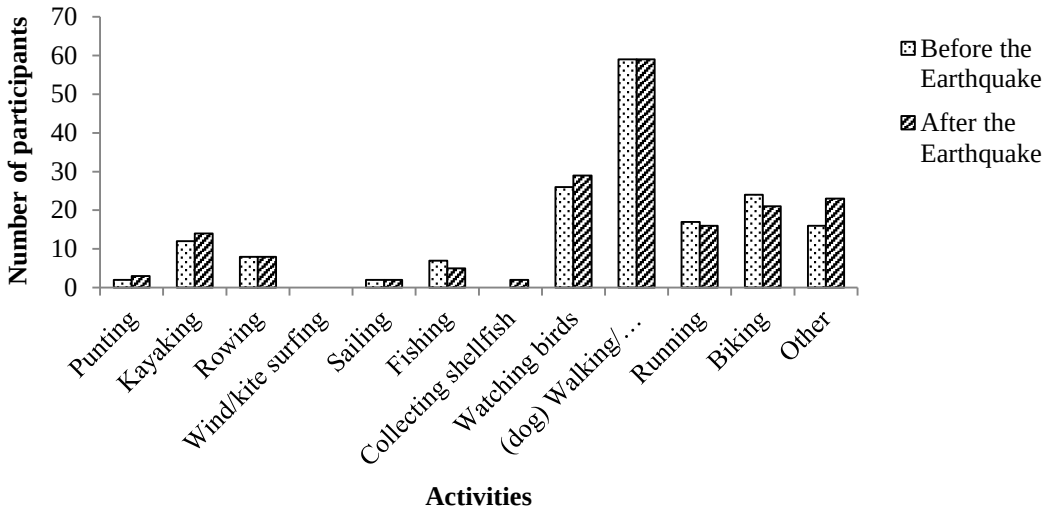
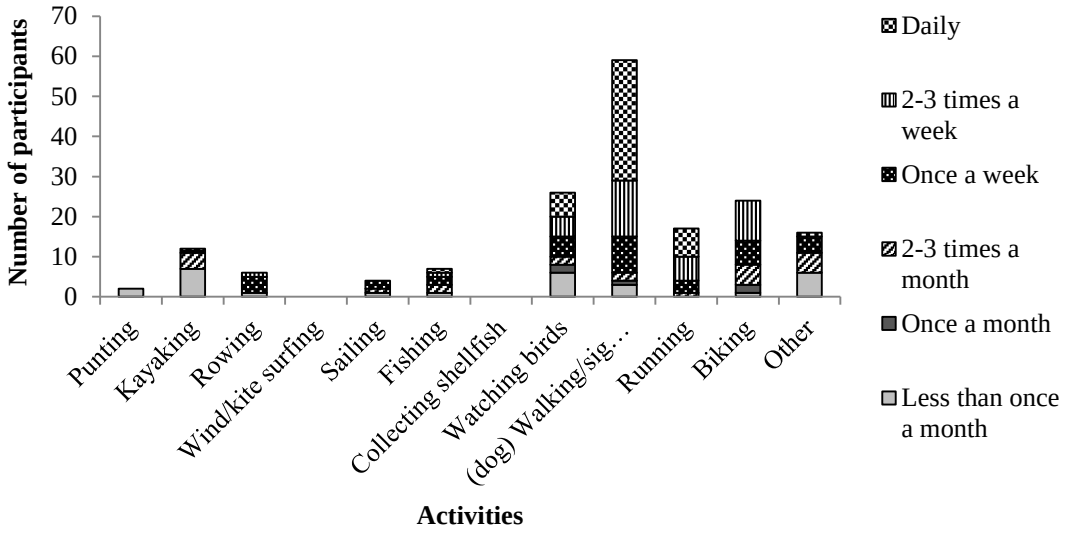


Figure 2.7 Recreational activities undertaken by participants before and after the 22nd earthquake.

The frequency of activities was similar pre and post earthquake (Appendix 5). The most frequent activity was (dog) walking/sightseeing (Figure 2.8a & 2.8b). In addition, some participants visited the locations once a week or 2-3 times a week for biking contrasting with kayakers which undertook this activity less than once a month.

2.8a



2.8b

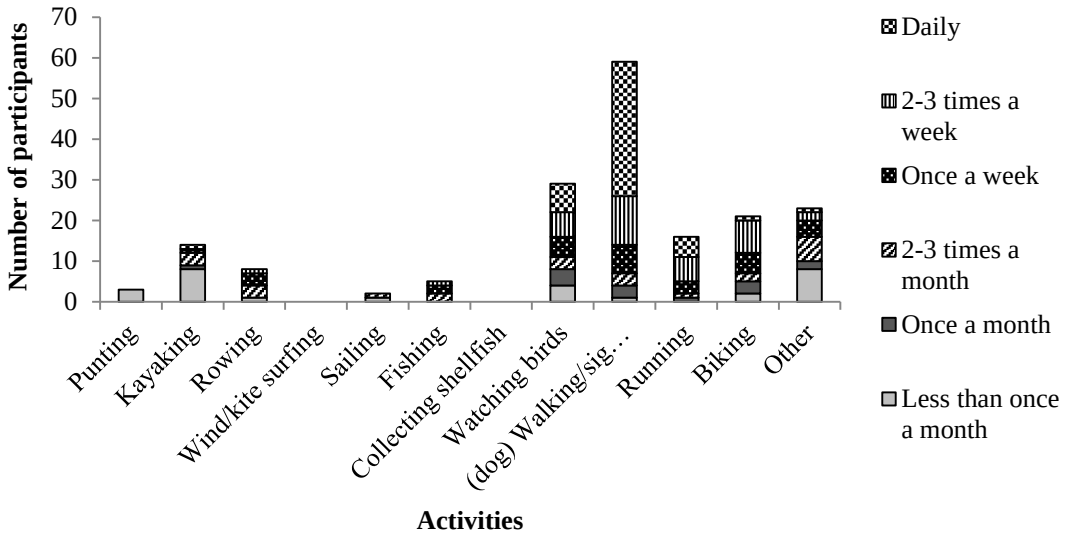


Figure 2.8 Frequency of undertaking recreational activities before the earthquake (a) and after the earthquake (b).

The earthquake activity during 2011 affected many recreational activities, so it was crucial to investigate what factors have impacted the enjoyment of recreation activities. Construction along the river and poor water quality have mainly made recreation unsatisfactory after the earthquake which each issue was claimed by over 90 participants (Figure 2.9). More than 70 participants mentioned that lack of footpaths was another critical problem, closely followed by access to the river.

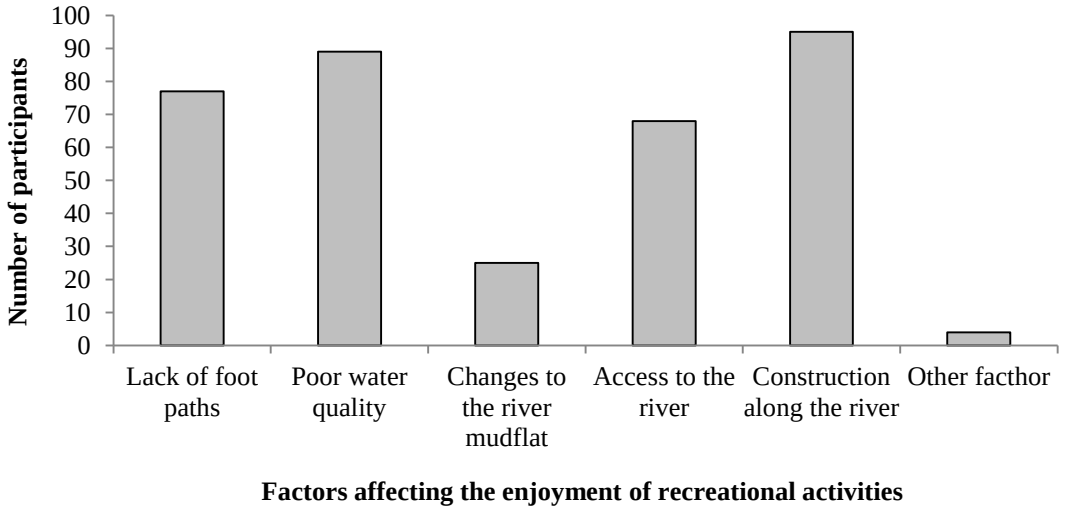


Figure 2.9 Factors affecting the enjoyment of recreational activities.

2.3.4 Perceptions of Water Quality

Before the earthquake, almost half (45%) of participants described water quality as good. Excellent water quality at that time was perceived by very few participants (4%) (Figure 2.10). In contrast, the majority of participants delineated the quality of water of the Avon River and the Estuary as poor 3-6 months post earthquake which consisted of 83%. At present, the percentage of participants thinking that water quality was good and reasonable was slightly different which included 35 % and 40% respectively.

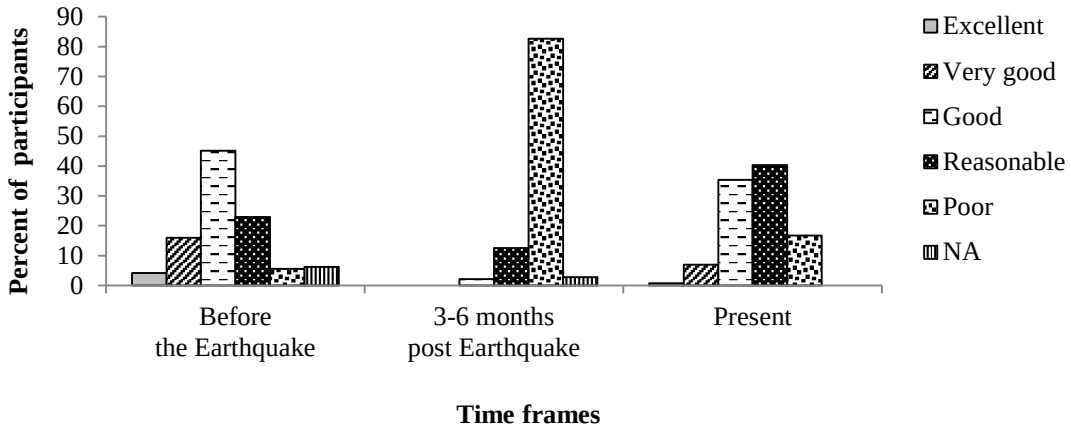


Figure 2.10 Opinion of participants on water quality of the Avon River and the Estuary at different times.

Water quality at the Botanic Gardens, Antigua Boatsheds and Moncks Bay was mainly perceived as reasonable to good. The water at Pleasant Point Jetty was described as poor to good. Kerrs Reach was the only location where participants mainly perceived the water as poor (Figure 2.11). Rowers and a few residents at Kerrs Reach mostly mentioned that nutrients, animal faeces and storm water run-off were key sources contributing to the degradation of water quality. Few recreational users at this location were influenced by the aesthetic appeals of water. For instance, they noted an excessive growth of weed and algae at the location as well as animal faeces that could be commonly seen on pontoons and along the river banks (Photo1 Appendix 8).

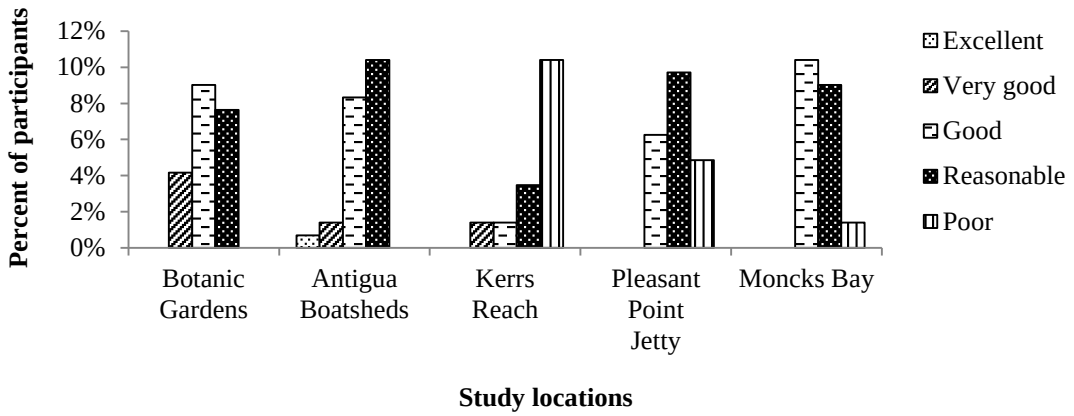


Figure 2.11 Opinion of participants on water quality of each study locations at present.

In general, water quality was seen as a concern more in older age groups (Figure 2.12). The peak percentage of concern (86%) was among participants aged 61-80. These concerns were based on the effects on health of human and animals. Another concern was water quality being influenced by effluent, nutrients from farming, storm water run-off, chemicals entering water as well as leakage of sewage, broken pipes and construction debris as a result of the Christchurch rebuild.

Causes of concern were also the impacts on ecosystem health, amenity values and recreational values of the river and the Estuary. For instance, some participants cited that the river and the Estuary provide habitats and feeding grounds for some animals, so poor water quality might lead to a decline in aquatic life such as whitebait, eels and trout. A few participants noted that the water was occasionally turbid and stinky.

It is also interesting to note that a few participants noticed more people visiting some locations and they hoped that people can still use the river and the Estuary in the future regardless any purposes.

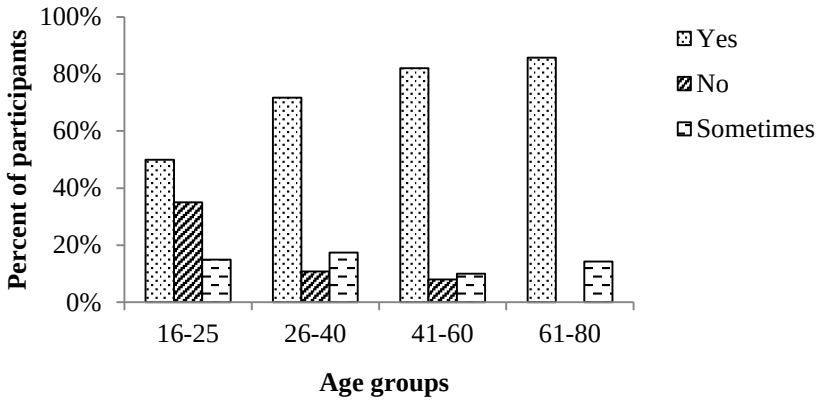


Figure 2.12 Concern of water quality.

2.3.5 Awareness of Bacterial Pollution and Knowledge of its Sources

The majority of participants in all age groups (except for 16-25) were aware that urban rivers and estuaries have a high incidence of harmful bacteria and viruses entering nearby waterways (Figure 2.13) and these were acknowledged as potential sources of bacterial pollution (Figure 2.14). Polluttion sources that particiapants were mainly aware of included sewage, storm water run-off, overflow of drains, silt, animal faecals and waste water from industries. Other sources related to construction particles, planks, rubbish, plants and animals decomposition.

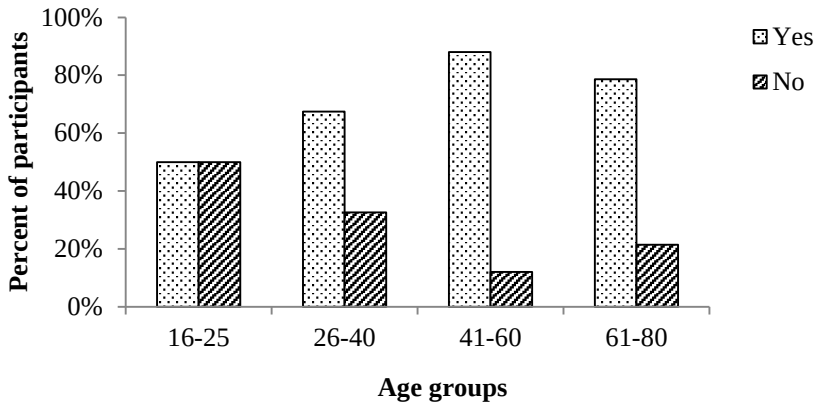


Figure 2.13 Awareness of bacteria and virus entering river and the Estuary.

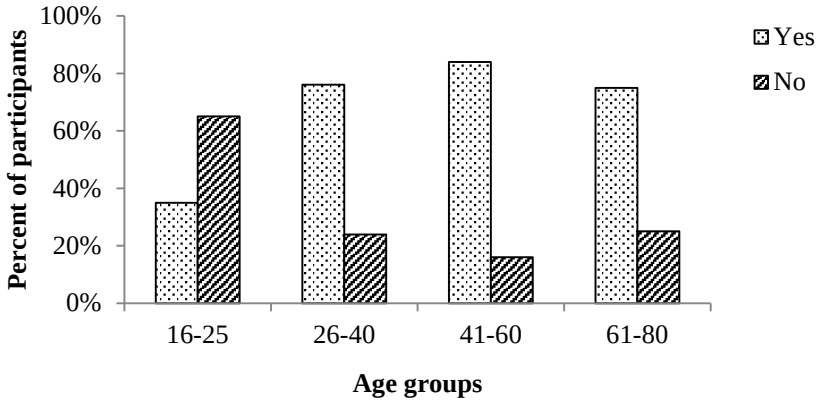


Figure 2.14 Knowledge of sources of bacteria pollution.

2.3.6 Health Risk Perceptions

More than 40% of participants with the age of 26-40, 41-60 and 61-80 perceived level of health risks as low, while 35% of participants aged 16-25 cited the health risks as medium or unsure (Figure 2.15). Furthermore, the proportion of participants aged 41-60 and 61-80 reporting high level of health risks was greater than other age groups.

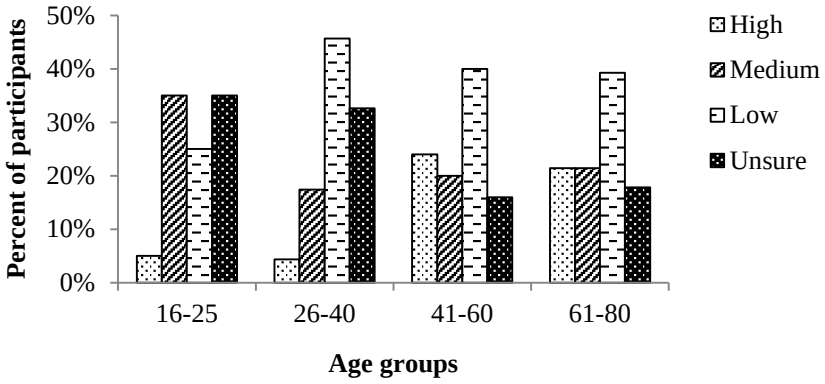


Figure 2.15 Levels of health risks.

2.3.7 Following of Information and Health Warnings about Bacterial Pollution and Information Sources

Participants were asked whether they followed information and health warnings about bacterial pollution that might influence their decisions about using the river or the Estuary for recreation or not. Overall, participants in all age groups (60%-80%) followed information and health warnings (Figure 2.16). There were, however, participants ignoring this issue, especially those in the age group of 16-25 that were higher than the other groups. Not getting into the water and perceiving the health risks as low were reasons of not following health warnings.

Some participants rejected information inlcuding health warnings because they needed to work in the Estuary and rowers also practiced on the Avon River in a few occasions. These people said that they usually washed their hands and equipment after use or they would take a shower if they had fallen into the river.

Other reasons given for not following health warnings were wanting to enjoy activities, managing post-quake stress, being crucial aspect for quality of life, saving expenses on food and not yet hearing about the issues.

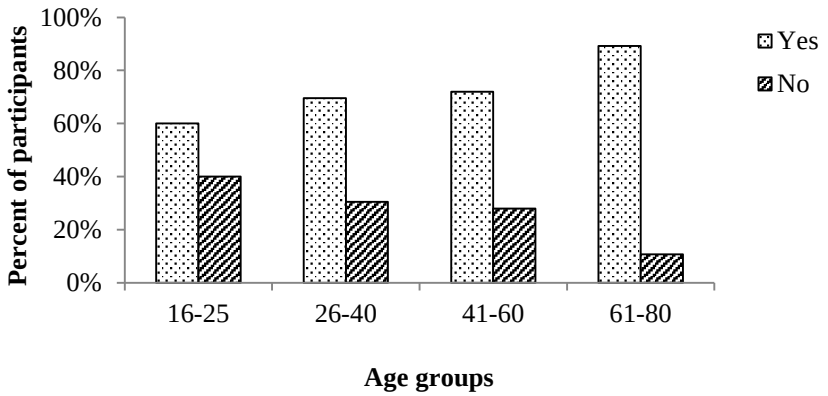


Figure 2.16 Following of information and health warnings.

An individual might utilise various sources of information to make decisions about using the river or the Estuary for recreation. For those who followed information and health warnings, they predominantly decided based on their own evaluation (120 participants Figure 2.17). Approximately 40-60 participants relied on information provided by Regional Council, friends, newspapers and other sources such as signs, CCC warnings, radio and local knowledge.

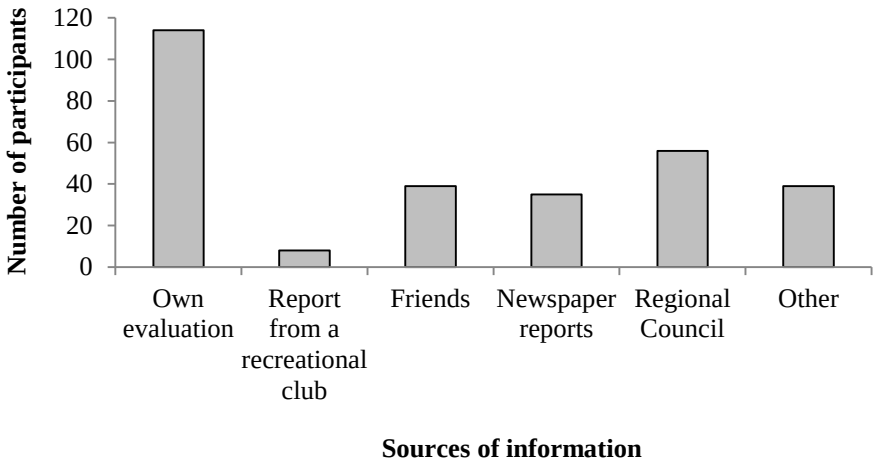


Figure 2.17 Sources of information.

2.3.8 Other Influential Factors in Decision Making

Besides information and health warnings about bacterial pollution, decisions about using the river or the Estuary for recreation also covered a range of other factors. As illustrated in Figure 2.18, weather condition was a factor that significantly influenced decisions made by more than 120 participants. The availability of facilities or resources was another key factor for making decision. Over half of participants considered about water aesthetics and proximity as well. Other influential factors involved tides, safety, costs of travel and so forth.

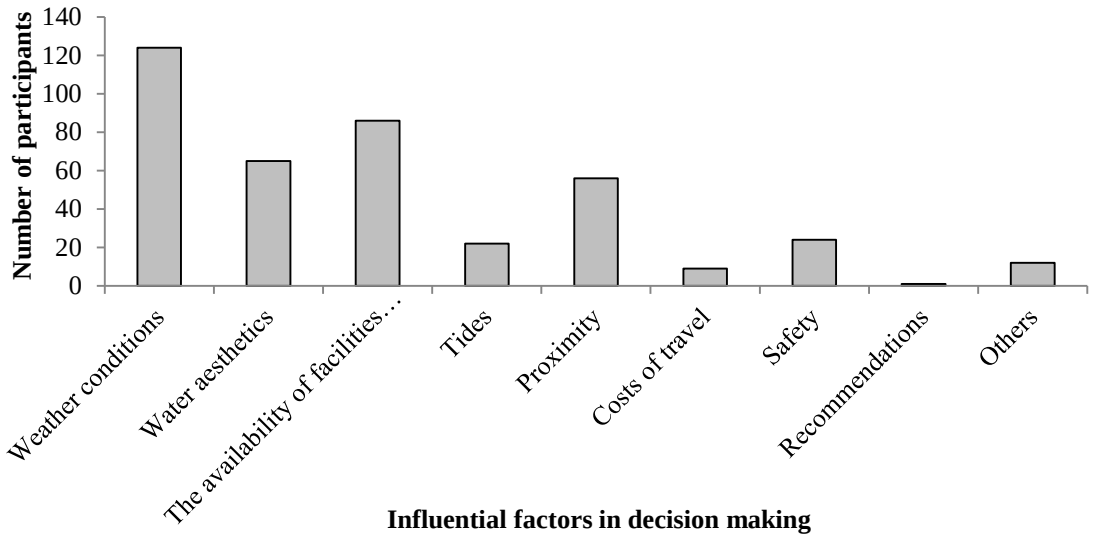


Figure 2.18 Influential factors in decision making.

2.3.9 Opinions on Recreational Resources and Facilities

Current Improvement of Recreational Resources and Facilities

The proportion of participants who thought that the resources available for recreational uses of the river and the Estuary are improving, and slightly improving was similar making up around 26% of the total (Figure 2.19). This was because some facilities, tracks, bridges, river and stop banks have been repaired; water appeared to be cleaner

than post earthquake; and more vegetation has been created. To give an example of this, the construction of “Watermark” at Antigua Boatshed was a great improvement mentioned by some participants. Such improvement involved increasing under-tree and river edge planting, enhancing the habitat of the river, installing high quality lighting and enhancing new pathways, boardwalks and seating areas (Chritstchurch Central Development Unit, 2014). A few participants reported better location access, safer places for recreation and acknowledgement of improvement plans.

On the other hand, the improvement of recreational resources and facilities has not been commonly carried out at all locations. Firstly, the amount of construction debris, rubbish and green waste could be found in the river. The problems of excessive growth of weed, algae boom, animal faecal material and silt were still present, particularly at Kerrs Reach. Furthermore, toilets and the jetty at Pleasant Point Jetty have not been fixed. Some participants from this location stated that it is necessary to get the infrastructure back on the ground like prior to the earthquake. People still kept utilizing the location for recreation even though limited options were available. Another issue was the repair works on bridges and access roads going on and on. Lastly, a small number of participants claimed that the improvement of recreation on the river and the Estuary was not a priority; focus was placed more on city rebuilds. All of these made participants considering that the resources for recreation have not yet improved.

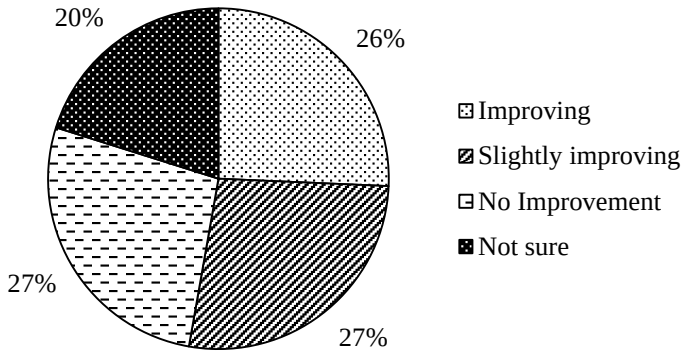


Figure 2.19 Opinions on current improvement of resources available for recreational uses of the river and the Estuary.

Future Improvement of Facilities or Infrastructures for Recreational Uses

Participants provided a broad range of facilities or infrastructures needing to be taken into consideration for the development of recreational uses in the future. Of over 50 participants, toilets, drinking water taps, changing rooms and hot showers were facilities that were recommended (Figure 2.20). It was suggested that footpaths should be made wider and safer since at all locations they are shared with walkers, runners and cyclists. Providing tables, benches and rubbish bins should be taken into account as well. Other facilities and infrastructures that should be developed included creating a water course for holding regattas, fixing boat ramps and jetty, constructing children playgrounds and building boardwalks along the river banks or ladders down to the river that can allow recreational users get close or bring boats to the river.

Additionally, a few participants mentioned that safe and attractive cyclist lanes should be created. For instance, a current improvement of separated cyclist land at the beginning of Main Road should be extended to Sumner.

Those participants answering “No” to this question were satisfied with the availability of facilities and infrastructures at the locations, which they mainly undertook activities at the Botanic Gardens and Antigua Boatsheds.

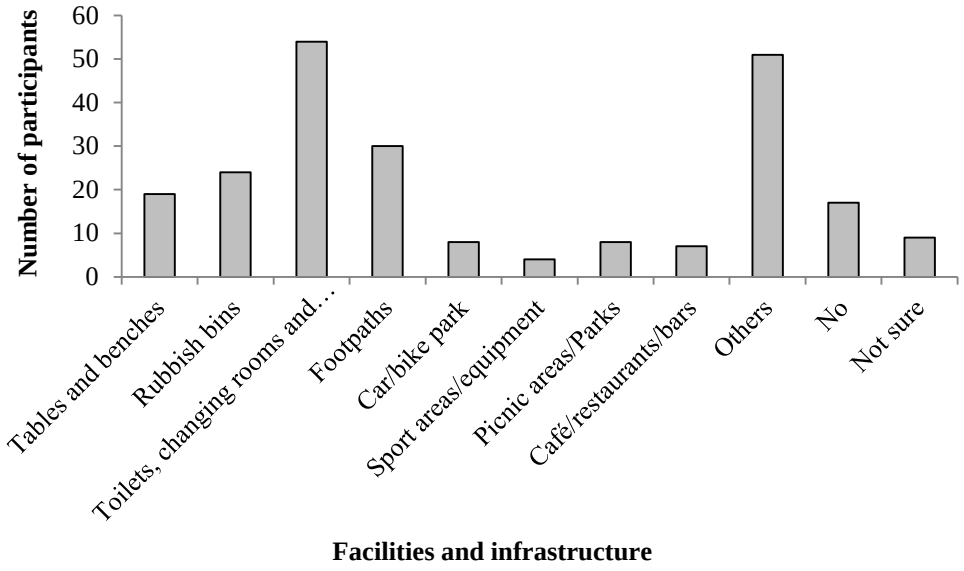


Figure 2.20 Opinions on the development of facilities or infrastructure for recreational uses of the river and the Estuary in the future.

2.3.10 Attitudes towards Future Development for the Hub of Recreational Activities

It is well known that the Avon River and the Estuary are ideal venues for recreation. There were some particular activities that participants desire for if the river and the Estuary will be developed for the hub of recreational activities. Significantly, 111 participants preferred water sports involving kayaking, rowing, punting, sailing and wind surfing. Land-based recreation was of great interest for a third of participants, especially walking, running, marathon and biking. Similarly, family oriented events or activities such as art and music festivals, markets, planting activities, parks, picnic and playground areas should be taken into account. Other types of recreation suggested related to fishing,

stand-up paddle boarding, swimming, camping, community focused activities and places for enjoying the aesthetic values of the river and the Estuary.

The reasons why participants desired for these activities being developed for the hub of recreation were associated with historical significance, character and identity of Christchurch, close proximity to their home, tourist attraction, personal interest and prevalence of some activities. Besides, some participants have considered that it would be graceful for Christchurch to host sport events or competitions across all levels. This would make the river and the Estuary being more attractive to Christchurch residents for gathering and enjoying sport games.

2.3.11 Other Comment Related to the Questionnaire

A broad range of comments provided by some participants (43 in total) was summarized in terms of key aspects of recreational uses of the river and the Estuary. Overall, the improvement of recreation in the river and the Estuary should be priority. Participants have not seen substantial development of recreation placing at most locations after the earthquake, and they have emphasized this work on local authorities to see the importance of the river and the Estuary for recreation. Furthermore, the enhancement of water quality was what participants emphasized in order to effectively support recreational uses in the City. It also needed to clean up water by removing construction particles and rubbish. Further prevention of construction debris entering into the water was important as well. Regarding the improvement of facilities, participants would like to see repair works that would bring back usable facilities like they had before the earthquake.

The public also commented on ecosystem health in general. This included preventing a decline in aquatic animals such as fish and eels as well as creating more green areas by putting more plantations on the river banks and areas within the Estuary, especially native plants. Lastly, participants stated that it was crucial to solve existing problems in order to prevent further deterioration to the water, natural and built environment of the river and the Estuary. It was also believed that the improvement of recreation would encourage the community to get back and use the areas for recreation and would attract more residents of Christchurch to visit and undertake a wide range of activities in the future.

2.4 Discussion

Questionnaires are useful for highlighting public perceptions on and issues of the use of recreational areas. Overall, recreational users in the Avon River and the Estuary were Christchurch inhabitants. The majority of participants were between 26-60 years old. Participants mostly carried out activities by themselves, while half of total participants also recreated with their family members and friends. This might be because activities undertaken by participants were related to social activities and family activities such as walking, biking, sightseeing, rowing, kayaking, picnicking, feeding/watching animals and playing at playground.

It was found that most recreational users favoured locations in close proximity to their residence locations even though there were many other places used for recreation in the river and the Estuary. This finding was also found in previous studies (Crawford & Fountain, 2010; Greenaway, 2007; Marquet & Duncan, 2012; McKenna, 1979). Regardless seasonal difference, main participants were those living within 5 km from the river locations and the Estuary locations. However, there were more participants

travelled by 500 m to Moncks Bay and Pleasant Point Jetty and by 1 km to Kerrs Reach in winter compared to summer. A similar finding to Crawford and Fountain (2010) was that most participants travelled by car, followed by walking. A use of car might have facilitated those who carried out activities with family and lived further than walking distance to recreational locations.

Land-based activities were important at all locations including (dog) walking/sightseeing and running, and the Botanic Gardens and Antigua Boatsheds presented a considerably great participation in feeding/watching ducks and passive recreation such as meeting friends, reading, sitting, having lunch, viewing the environment and watching activities. Meanwhile, lesser amount of participants undertook water-based activities such as punting, kayaking, rowing, sailing, fishing and collecting shellfish. In the Estuary, shellfish at some sites are not safe to eat such as Shag Rock, Sandy Point and Penguin Street (Bolton-Ritchie, 2014). Hence, this might have influenced low participation in collecting shellfish.

The majority of participants performed recreational activities throughout the year, but patterns of recreation were different between summer and winter for some locations. The frequency of some activities was also influenced by seasons. Participants who performed (dog) walking/sightseeing, running and watching birds tended to undertake the activities more frequent in summer, which was daily or 2-3 times a week. Fishing was carried out by participants more often in summer, which was 2-3 times a month. Difference in recreational use between seasons might have been caused by weather conditions. In winter, there were cold temperatures and more rainfalls, while in summer temperatures were warm and there were more sunlight.

The February 22nd earthquake substantially impacted recreation along the river and the Estuary, and it interfered with recreation of almost three quarters of participants who have performed recreational activities one year before the earthquake until present. It was found that just over 18 months since the February 22nd earthquake, participation rates of sport and recreation across Christchurch continue to be below participation rates in 2010 (Sport and Recreation Earthquake Leadership Group, 2013) . Participants ceased their activities post earthquake during the Estuary closure in 2011. Activities continued to be reduced for some time after the closure was lifted. This continued reduction was not enforced, but was observed. Activities on river locations were also lessened. Nevertheless, most participants are eventually able to return to use the river and the Estuary for recreation even if a few activities face some obstacles, so there were minor changes to paticipation in most activities in the river and the Estuary. When compared frequency of activities pre earthquake to post earthquake, it was found that participants have currently undertaken recreational activities as frequent as pre earthquake.

The results showed that people responded differently to the earthquake. The earthquake activity has brought about factors impacting the enjoyment of recreational activities of participants. Such factors included construction along the river, poor water quality, lack of footpaths and access to the river. According to McCrone (2015), it was reported that Christchurch residents have experienced stress from the earthquake impact. Cause of stress include issues related to transport, being in a damaged environment and/or being surrounded by construction work and the loss of recreational, cultural or leisure-time facilities.

In terms of perceptions of water quality, 45% of participants perceived the water as good before the earthquake, while most participants perceived the water as poor 3-6 months

post earthquake and reasonable to good at present. Perceived water quality 3-6 months after the earthquake was consistent with the finding in the previous study (Marquet & Duncan, 2012). Additionally, the investigation of water quality at each location perceived by participants at current showed that water quality at the Botanic Gardens, Antigua Boatsheds and Moncks Bay was mostly perceived as reasonable to good. The water at Pleasant Point Jetty was perceived as poor to good. Moreover, the majority of participants perceived the water as poor at Kerrs Reach.

In the literature, age, personal usage of water, familiarity with contaminants and sources are among those factors affecting public perception of water quality (Canter et al., 1992). Spatial patterns can influence perception of water quality (Brody et al., 2005). In the present study, participants at Kerrs Reach involved rowing club members and many of those living within 5 km. These participants have frequently been recognized about ongoing problems of this location such as excessive growth of aquatic plants and algae, silt accumulation, sewerage discharge from upstream, high levels of faecal contamination and abundant amount of waterfowl. Some of these problems also distracted aesthetic appearance of the water at this location. Further investigation of water quality concern in the present study revealed that older age groups expressed more concerns about water quality in which influence on health of human and animals were key causes of concern. This similar finding was also noted in a study by Marquet and Duncan (2012). For example, participants who undertook onshore activities were concerned about the risk of becoming sick from entering the water by their dogs. This aspect was stating that the concern of walkers, who often walked with their dogs, was about the safety of the water for their dogs. Meanwhile, some participants were concerned about ecosystem health, amenity values, recreational values, water appearance and odours. Some of these factors were reported by Patrap (2011) that aesthetic values such as odours, colour of the water,

cleanliness and other key visible factors influenced water quality perceptions. Nare et al. (2006) also noted that physical characteristics of water quality were often concerned by residents in Mzingwane catchment in Zimbabwe.

Awareness of bacterial pollution in urban rivers and estuaries was significant among most participants in all age groups (except for 16-25). Most paticipants in these age groups had knowledge about key sources of bacteria such as sewage, storm water run-off, overflow of drains, silt, animal faecals and waste water from industries. Even though theses participants were aware of bacterial pollution and its sources, health risks were perceived as low, whereas 35% of participants aged 16-25 perceived the health risks as medium and unsure. In Christchurch, many people were recorded having gastrointestinal illness and posed to risk of infection due to damaged water supply and sewage disposal systems cause by the earthquake (Johnston, 2011). This might be why some public were still unsure about health risks of entering the water.

It was noted that participants in all age groups (60%-80%) followed information and health warnings about bacterial pollution that might influence their decisions about using the river or the Estuary for recreation. People have a level of control whether the risks are acceptable and voluntary. Participants who did not follow gave reasons in association with not getting into water, perceiving the health risks as low, needing to work in the water, enjoying activities, managing post-quake stress, being crucial aspect for quality of life, saving expenses on food, not having other suitable placses for rowing in Christchurch and not yet hearing about the issues.

In general, participants utilised more than one source of information to make their decisions about using the river or the Estuary for recreation. It became evident that the majority of participants decided based on their own evaluation. The use of information

provided by regional council, friends, newspepers and other sources (such as signs, CCC warnings, radio and local knowledge) was also included in decision making by some participants. However, Marquet and Duncan (2012) found that the information on the general suitability for contact recreation, from the view of an information seeker, does not provide a definite answer on whether or not to enter the water. Additionally, decisions were also influenced by several factors involving water aesthetics, proximity, the availability of facilities or resources and weather conditions, which were other important factors for most participants. Tides, safety, costs of travel were considered for decision making by a few participants.

When considered current improvement of recreational resources and facilities, there were a similar number of participants thinking that the resources available for recreational uses of the river and the Estuary are improving and slightly improving. This can be seen through the improvement of water quality, some facilities, tracks, bridges, river and stop banks and vegetation. The construction of “Watermark” has greatly been appreciated by some participants. Adversely, a similar proportion of participants also expressed that no improvements have been made due to the presence of construction debris, rubbish, green waste, excessive weed growth, algae boom, animal faeces and silt as well as broken facilities such as toilets and the jetty at Pleasant Point Jetty. In recovering from the earthquake events, greater Christchurch is facing challenges that influence sport and recreation. One of those issues is the gap between the expectations of stakeholders and what can be delivered in terms of replacement in the short term (0-3 years) and the medium term (4-10 years) and enhancement of places and spaces in the long term (10+ years) (Sport Canterbury, 2011). A few participants mentioned that the improvement of recreation on the river and the Estuary was not a priority. This was noted by T. Williams and Mackay (2013) that a priority area for local authorities considerations was the central

city or other red-zoned areas, not location in the study. Other issues related to ongoing repair works on bridges and roads.

For future development of recreational uses, a number of facilities or infrastructures have been suggested for considerations. These involved building toilets, drinking water taps, changing rooms and hot showers; creating wider and safer footpaths; accommodating tables, benches and rubbish bin; creating course for holding regattas, fixing boat ramps and jetty, constructing children playgrounds and building boardwalks along the river banks or ladders down to the river that can allow recreational users get close to or bring boats to the river. The development of a cycling and walking trial is a well-supported proposal that tends to be popular and well-used. It is also stated that the route must be made safe by creating complete separation between walkers and cyclists as well as building a high level of features, facilities and good access with facilities such as a sealed surface, wide path, bike parking, toilets, car parking and public transport (Looy, 2013).

The Avon Sport and Recreation Hub, which is one of priority development projects presented in the Spaces and Places Plan, has been proposed for flat water course for training and shore facilities (immediate, 1-3 year plan) (Sport and Recreation Earthquake Leadership Group, 2013). Creating a facility to meet the current and future demand from rowing and other sports for a safe training facility would be an option for Christchurch (Sport Canterbury, 2011). To meet training demand, it is also vital to accommodate a competition course into the water area. Options for water recreation and sport on the Avon River would be new and shared club facilities, potential new recreational rowing and kayaking areas (Sport Canterbury, 2011).

The development of the Avon River and the Estuary for the hub of recreation was of interest of participants in general. Water sports including kayaking, rowing, punting,

sailing and wind surfing were primary activities that a large number of participants desire to see most because some of these activities have been considered as historical significance, character and identity of Christchurch and tourist attraction. Sport and recreation bring events, tourism and other industry into the greater Christchurch areas (Sport Canterbury, 2011). Other important consideration of activities were in association with land-based recreation, especially walking, running, marathon and biking since these activities are prevalent in Christchurch. By looking at population trends relevant to sport and recreation, it is illustrated that changes of demand for particular types of sport and recreation such as walking tracks have appeared to be among an aging population, especially large numbers of older adults (Sport Canterbury, 2011).

It was also suggested by some participants that the hub of recreation should integrate family oriented events or activities such as art and music festivals, markets, planting activities, parks, picnic and playground areas. For example, the community at South New Brighton have arranged events such as tree planting days and Christmas Carols in the Park (T. Williams & Mackay, 2013). Desired activities were also based on personal interest of participants and close proximity to their home. Further recommendations included fishing, stand-up paddle boarding, swimming, camping, community focused activities and places for enjoying the aesthetic values of the river and the Estuary. The information might be beneficial for the development of the Avon Sport and Recreation Hub (1-3 year, 4-10 year, 10+ year plans) (Sport and Recreation Earthquake Leadership Group, 2013). Some participants mentioned that the river and the Estuary will be more attractive to Christchurch residents for meeting and relishing sport games if sport events or competitions across all levels will be held in Christchurch. This notion is consistent with expected long-term outcomes of the Spaces and Places Plan that is to bring about suitable spaces and places for hosting major sport and recreation events to attract

inhabitants and visitors. Sport and recreation are vital to the communities with greater Christchurch in contributing to social cohesive, social capital, health and community development outcomes as well as in defining Canterbury's identity (Sport and Recreation Earthquake Leadership Group, 2013). Water is a powerful social force and provokes the senses (Pryor, 1984).

Chapter 3

Public Participation in Recreational Activities

3.1 Introduction

Recreation is essential for human well being and undertaken for enjoyment and quality of life (Godbey, 2009; D. R. Williams & Patterson, 2008). Worldwide recreational areas are provided in cities and wild-life areas such as national parks. Waterways and urban parks provide opportunities for recreation, leisure and cultural activities for a community (Chicago Park District, 1989; Colby, 1989; More, 1985). New Zealand has numerous rivers, lakes and estuaries that provide a variety of recreational opportunities for its inhabitants and overseas visitors (Robb & Bright, 2004). In Christchurch, waterways and their surroundings areas are greatly valued for recreation because they contribute to the enhancement of community identity, psychological and physical wellbeing, family well being and social relationships (Environment Canterbury & Christchurch City Council, 2011; Shafer & Floyd, 1997; Vallance et al., 2005).

Christchurch is located in the eastern South Island that has the climate influenced by the ocean and the Southern Alps to the west. In summer, temperatures are warm, but for much of the time temperatures are lowered by a cool sea breeze from northeast. Daytime highest air temperatures in summer typically start from 18°C to 26°C. There might be occasions where temperatures can mount to greater than 30°C in summer. In winter, temperatures are cold with frequent frost. Daytime highest air temperatures in winter normally start from 7°C to 14°C. Mean rainfall is low annually, and the appearance of long dry spells can be observed in summer in particular (National Institute of Water and Atmospheric Research, 2013).

There has been considerable previous research on recreational patterns of people in relation to age, gender, socio-economic variables, cultural background, ethnicity and races. Community parks in most cities encourage physical activity of people of all ages (Bedimo-Rung et al., 2005; Centers for Disease Control Prevention, 1997; Henderson & Ainsworth, 2001; Orsega-Smith et al., 2000). Age was not a factor decreasing recreational interest, but the number of activities as one grows older. Occupation, income, social class status and sex have also influenced recreational behavior (Sessoms, 1963; Singleton, 1984). Singleton (1984) emphasized that the outdoor recreational activities have a robust relation with these variables rather than age. Besides, Sasidharan et al. (2005) investigated cultural differences in urban recreation patterns across six population subgroups and indicated that major group oriented activities occurred in urban parks and forests. Participation in recreational areas on weekends surpassed weekdays except for public holidays (Boden & Ovington, 1973; Sasidharan et al., 2005).

The majority of recreational research in the Avon River and the Estuary has been undertaken in summer. Taylor et al. (2004) interviewed people undertaking recreational activities in the study area (as cited in T. Williams & Mackay, 2013). Respondents were asked to identify the main values they saw in the Estuary and the results showed that scenic views, bird life, peace and quiet, recreational opportunities and the proximity to their place of residence were highly valued.

The Estuary Walkway, “the Spit” and South New Brighton Park were among the most popular places at the Estuary (Crawford & Fountain, 2010; Greenaway, 2007). Greenaway (2007) also found that the greatest levels of activity were recorded between South New Brighton Park and “the Spit”, and the former was one of the most prevalent entry points to the Estuary. Furthermore, South New Brighton Park, the Estuary

Walkway and the jetty were regarded as some of the most favourite places around the Estuary. These venues have features and opportunities as well as scenic, natural and peaceful aspects that were appreciated by many participants. In the present study, we refer to South New Brighton Park as Pleasant Point Jetty.

A study on recreational pursuits will provide information on recreational uses of Christchurch wetlands. The information gained might be useful for the management and planning of recreation that will effectively serve the community. This research compared recreational participation at 5 locations in winter and summer in the Avon River and the Avon-Heathcote Estuary. It was predicted that activities would be location specific and participation levels would be higher in summer than in winter.

3.2 Methods

The five study locations are the same as those previously described in chapter one. At the Botanic Gardens, recreational activities were noted at an area near new Botanic Gardens Visitor Center, Armagh Footbridge and West Bridge (Appendix 1). Recording of the activities at Antigua Boatsheds were carried out at three locations, one close to Christchurch Hospital and another two locations were within Watermark. For observing recreational activities at Kerrs Reach, one location was located upstream on Avonside Drive. The other two locations were in front of Canterbury Rowing Club and a short distance downstream. At Pleasant Point Jetty, the observations were made at Picnic Area F, Picnic Area E close to children's playground and an area near the jetty. Recreational activities at Moncks Bay were recorded at a parkingarea next to Christchurch Yacht Club. To ensure that people performing recreational activities along Main Road were also noted, observations were conducted on the Estuary Walk, a location close to a bird

watching house and at a bridge. Even if there were a few boats anchoring near the shore in winter, they were not counted.

Recreational activities were recorded by using a manual recording sheet adapted from System for Observing Play and Recreation in Communities (SOPARC) (McKenzie et al., 2006) (Appendix 7). SOPARC is a reliable and feasible instrument for assessing physical activity including the number of participants, physical activity levels and associated contextual information on the setting whether it is accessible, usable, supervised or organised. The information recorded included age group, gender, the number of participants in each activity and weather. Information on race and physical activity levels were not recorded. At times of high recreational activities, an audio recorder was used to assist in recording the information, the information was noted on the recording sheet once the observation was completed. Also, a binocular was sometimes utilized to assist in seeing recreational users from a further distance.

Observations of recreational activities were undertaken three times in winter 2014 and summer 2014-2015 at three locations within the five study locations (Appendix 1). Recording of recreational activities at each location were undertaken twice on weekends and once on weekdays. This was because more activities occurred on weekends rather than weekdays. The collection of data was completed within three hours in which an hour was spent at each location. At river locations, the locations were selected to observe activities on both sides of the river. The observation at all locations occurred on different times of the day (eg. 8 am–11 am, 11 am–2 pm and 2 pm–5 pm) to capture different recreational activities. In particular, recording of levels of recreational participation on weekdays was undertaken from 2 pm-5pm.

3.2.1 Data Analysis

Data gathered from field observation were entered in a spreadsheet and analysed using Microsoft Excel. ANOVA was used to compare mean levels of participation of various activities and to compare results between locations as well as seasonal differences between winter 2014 and summer 2014-2015. Chi-square tests (Appendix 6) were also utilized to investigate differences between age groups, gender and types of participation between both seasons.

3.3 Results

Observations of recreational activities were completed on 31st August 2014 in winter and on 2nd January 2015 in summer. For both seasons, levels of participation in recreation on the weekends were greater than weekdays for most locations. The exception was Antigua Boatsheds where there was a higher frequency of visitation on one single weekday in summer. On weekends, levels of participation in recreational activities from 11am-2pm were higher than those from 8am-11am. During winter, the weather on most observation days was cloudy, humid and wet. The temperature was cold and recorded from 7°C to 14°C. Little sunlight usually appeared later in the afternoon. Recreation was sometimes affected by rainfall in winter. In summer, there was mainly warm, sunny, clear weather although on a few occasions it was cloudy. The temperature ranged 8°C to 26°C. Activities in summer were sometimes impacted by strong wind.

All five recreation areas were accessible and usable all the time. However, there was one occasion where an area near the hospital and the bridge at Antigua Boatshed was closed to the public in summer (Photo 2 Appendix 8). Even though constructions of buildings, bridge and road at Antigua Boatshed and Kerrs Reach had restricted access,

recreationists were still able to visit them from other access points. At Pleasant Point Jetty, accessibility was limited by fences, land clearance or fallen trees, but people could still access the jetty. At all locations, organized and supervised activities were rarely observed. Also, there was no sport equipment publicly accessible. People always presented at the observation times, but few were seen directly after rainfall. Similarly, smaller numbers of recreationists were recorded on wet or quite humid days.

3.3.1 Socio-demographic Information

Generally, group participation in recreation was greater than participation of individuals in both seasons (Figure 3.1). A chi-square test (Appendix 6) showed that there was a statistically significant difference in participation between individuals and groups for both seasons. For example, the mean participation in recreation by an individual was about 43 people in winter and around 63 people in summer. Much higher level of group participation was observed in summer compared to winter, where the average number was 123 people and 206 people respectively.

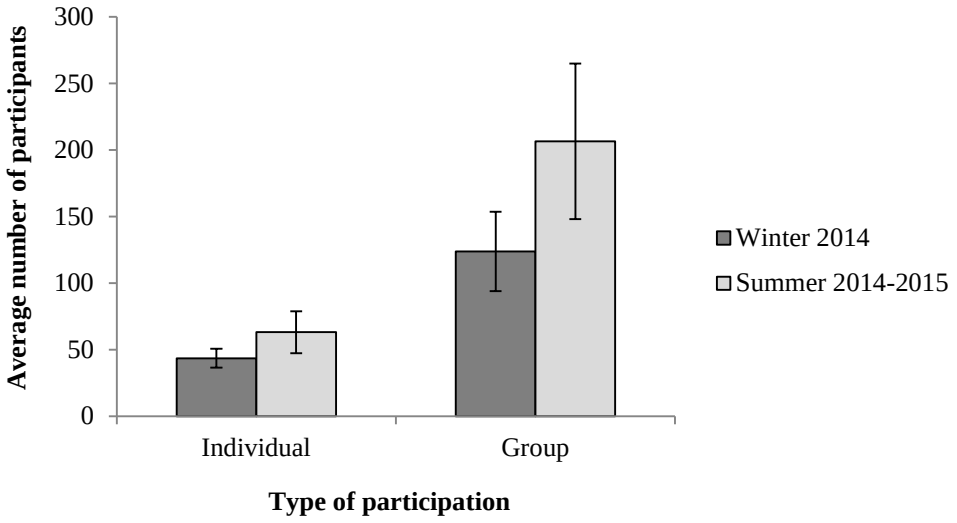


Figure 3.1 Individual and group participation in recreational activities in winter 2014 and summer 2014-2015.

There were differences between levels of participation of males and females in each season (Appendix 6). The level of female participation in recreation in winter was about 80 people on average, whereas level of female participation in recreation in summer was 139 people (Figure 3.2). The mean participation in recreational activities by males was approximately 88 people in winter and around 131 people in summer.

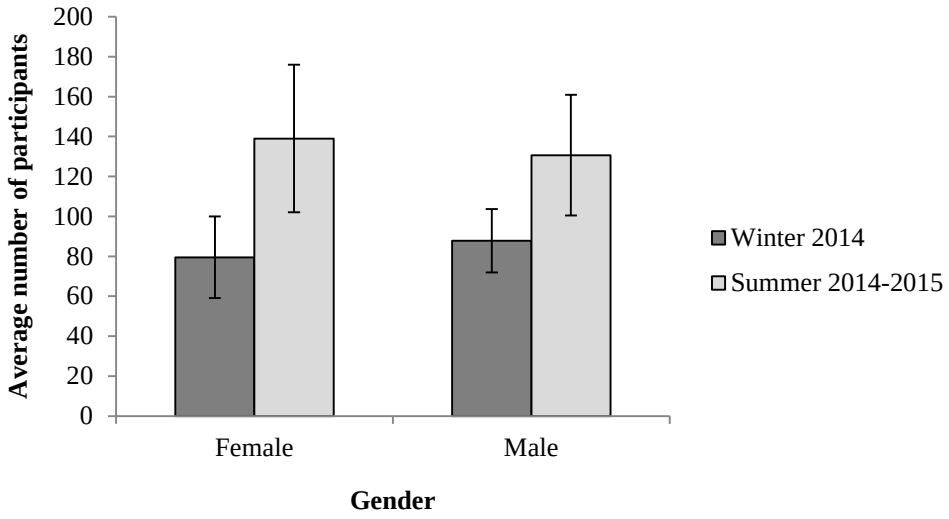


Figure 3.2 Female and male participation in recreational activities in winter 2014 and summer 2014-2015.

Levels of participation in activities were recorded for four age groups including children (15 and below), teens (16-30), adults (31-60) and seniors (61 and above). The result from chi-square test (Appendix 6) displayed that there was no statistically significant difference in recreational participation among these groups between both seasons. It was found that people aged 31-60 years old had the greatest level of participation in recreational activities in both seasons. The average number of participation of all the other groups was quite similar.

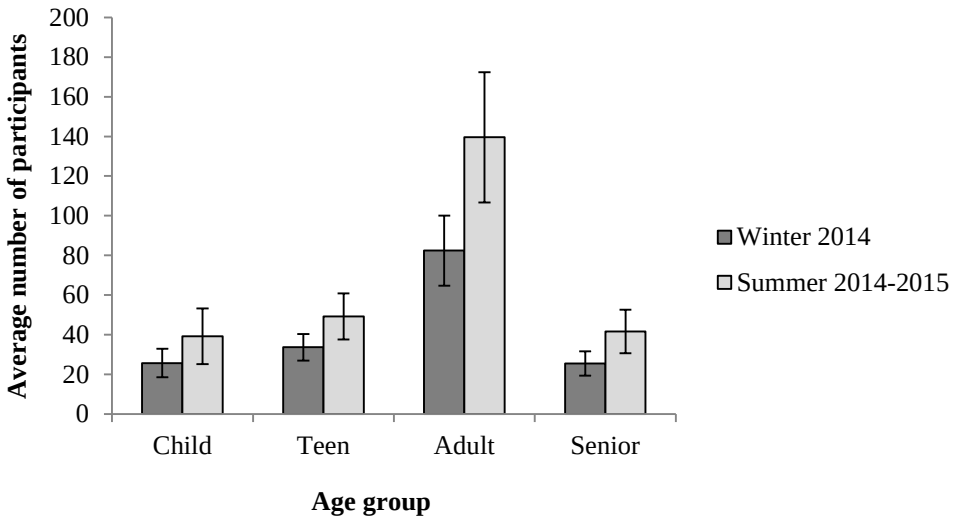


Figure 3.3 Participation in recreational activities among different age groups in winter 2014 and summer 2014-2015.

3.3.2 Walking/Sightseeing

There was no substantial effect of season on participation in walking (ANOVA *F*= 2.9 P<0.5), but there was statistically significant difference between locations (ANOVA *F*= 24.6 P>0.5). Generally, the levels of participation in walking in summer were higher than winter at all locations with the exception of Pleasant Point Jetty (Figure 3.4). The Botanic Gardens had the highest participation in walking in both seasons, which was 349 people on average, while walking at Kerrs Reach appeared to be lowest with average participants of 10 people. Armagh Footbridge and West Bridge were the most popular entry points to the Botanic Gardens because there were large parking areas close to these bridges. The greatest levels of activity were recorded at the area near Armagh Footbridge where a large number of participants walked along both sides of the Avon River. Several participants visiting the café at the new Botanic Gardens Visitor Center and playground were also recorded since they used footpaths along both sides of the river and walked past the bridges. On weekdays at around 5 p.m, recreationists who walked or cycled along the river were mostly people who commuted from work.

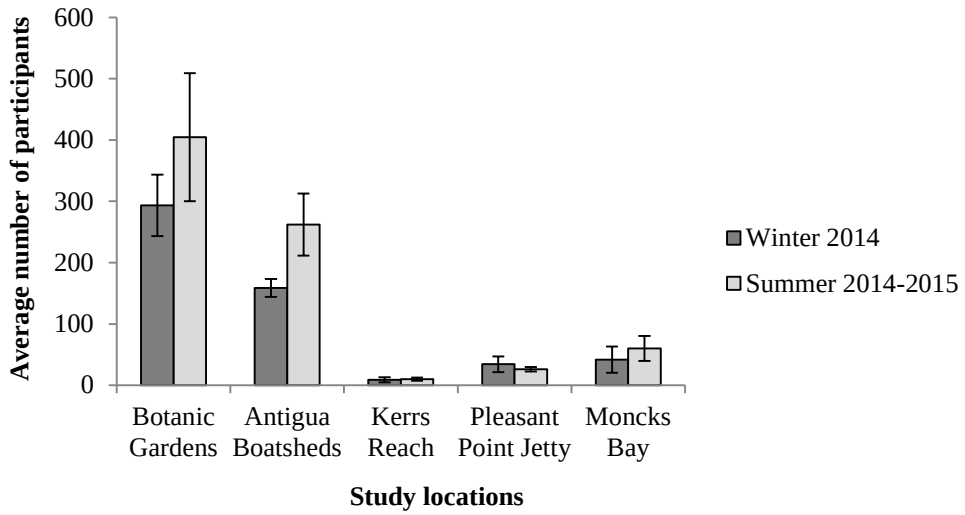


Figure 3.4 Levels of public participation in walking in winter 2014 and summer 2014-2015.

3.3.3 Running

For running, there was no effect of season on participation (ANOVA F= 0.2 P>0.5), but there was statistically significant difference between locations (ANOVA F= 6.8 P<0.5). There was greater participation in running at most areas in summer than in winter (Figure 3.5). The mean participation in running in both seasons at the Botanic Gardens was similar to Antigua Boatsheds. The highest participation in running was recorded at an area near the hospital at Antigua Boatsheds where there was a bridge connecting between Antigua Boatsheds, the Botanic Gardens and Hagley Park. It was observed that a large number of recreationists ran past the bridge to the other locations. In contrast, Kerrs Reach was the location where running was undertaken the least.

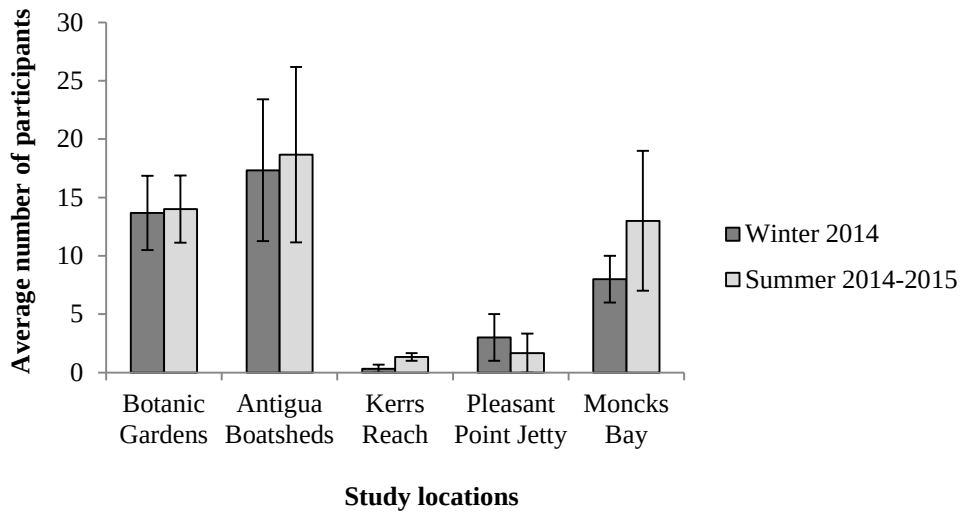


Figure 3.5 Levels of public participation in running in winter 2014 and summer 2014-2015.

3.3.4 Biking

Biking activity was similar between the season (ANOVA F= 3.8 P>0.5), but there was a significant location effect (ANOVA F= 11.2 P<0.5). Moncks Bay had the maximum participation in biking in both seasons, which were 91 people on average (Figure 3.6). Main Road runs along the shore at this location, and a great number of people including cyclists use this road to travel to Sumner.

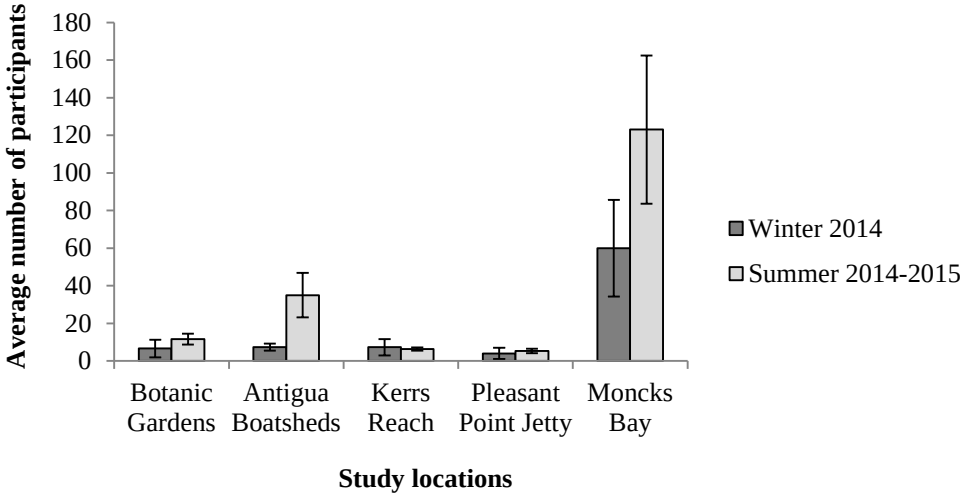


Figure 3.6 Levels of public participation in biking in winter 2014 and summer 2014-2015.

3.3.5 Boating Activities

Boating activities included punting, kayaking, rowing, canoeing, sailing and jet skiing. The levels of public participation in boating activities were significantly different in winter and summer (ANOVA F= 8.8 P<0.5) and location was also a significant factor (ANOVA F= 10.2 P<0.5). Most boating activities took places at Antigua Boatsheds with a mean participation of 56 people. The number of participants who commenced these activities at this location in summer was substantially higher than winter, which was a mean of 30 and 81 people respectively (Figure 3.7). Antigua Boatsheds is a place where boats are available for hire involving kayak, canoe, Canadian, paddle boats, row boats and punting which is normally arranged as a guided punt tour along the Avon River through the Botanic Gardens (Photo 3 and Photo 4 Appendix 8). At Kerrs Reach, there were more rowers and kayakers found in summer. Rowing was supervised by official personnel from rowing clubs. Rowers usually practiced for 2 hours and 6 times per week in summer, while training in winter was usually carried out for an hour after school and 3 times per week. It was noted that rowers who practiced in winter were mostly teenage members of rowing clubs, while rowing included more club members from different age groups in summer.

In addition, boating activities including sailing, kayaking and jet skiing occurred at Moncks Bay in summer. Sailing was usually organized and supervised by Christchurch Yacht Club at high tide on weekends and observed more frequently than kayaking and jet skiing (Photo 5 Appendix 8). Also, it was noted that sailing was mostly undertaken by teenage members from the Christchurch Yacht Club. The average level of participation in boating activities was 24 people in summer. Only one kayaker was observed at Pleasant Point Jetty in summer.

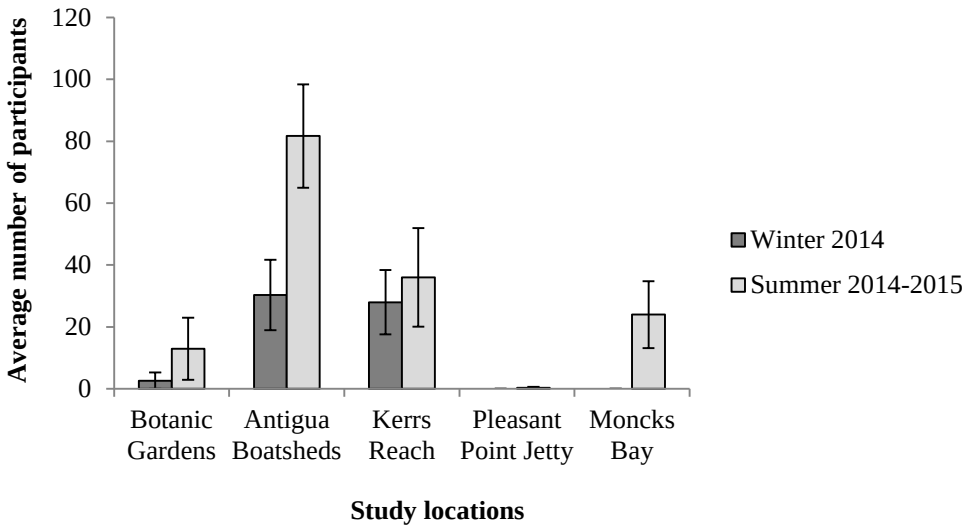


Figure 3.7 Levels of public participation in boating activities in winter 2014 and summer 2014-2015.

3.3.6 Fishing and Collecting Shellfish

No fishing was recorded at the Botanic Gardens and Antigua Boatsheds since fishing is prohibited in the Avon River from the Armagh Street Bridge to the Barbadoes Street Bridge and within the Botanic Gardens (Christchurch City Council, 2011). There was no significant effect of season on fishing (ANOVA F= 0.1 P>0.5) and location was not a factor impacting this activity (ANOVA F= 2.4 P<0.5). There were very few people undertaking fishing and hunting except for whitebait in winter at Kerrs Reach (Figure 3.8). At Pleasant Point Jetty, fishing only occurred in summer. People commonly fished at the Jetty even though access to it was prohibited. The level of participation in fishing at Moncks Bay was higher than all the other locations in both seasons. Some people collected shellfish at Moncks Bay in winter, while overall there were more people fishing in summer. Photo of these activities were shown in (Photo 6 Appendix 8).

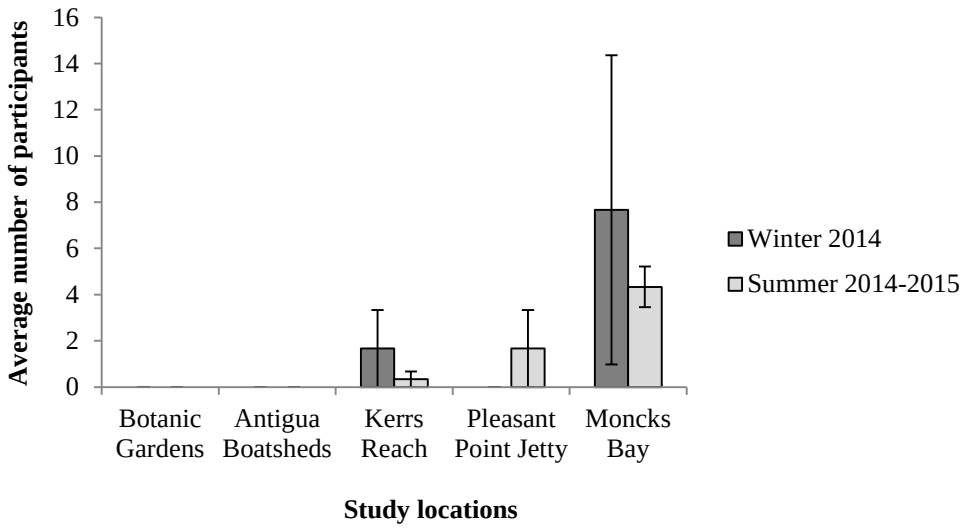


Figure 3.8 Levels of public participation in fishing in winter 2014 and summer 2014-2015.

3.3.7 Swimming and Standup Paddle Boarding

These activities were only recorded in summer at Moncks Bay. Very few people were observed swimming at this location. Standup paddle boarding was generally carried out both during low tide and high tide, but more number of participants were observed during high tide. Participation levels of these activities were usually less than sailing. The total number of participants who swam and undertook standup paddle boarding at Moncks Bay were 23 in summer.

3.3.8 Other Activities

For other activities, there were no significant differences in participation between the season (ANOVA F= 1.7 P>0.5), but there was a significant location effect (Figure 3.9 ANOVA F= 6.6 P<0.5). The Botanic Gardens had the maximum participation in other activities for both seasons, followed by Antigua Boatsheds. The mean number of participants was 140 at the Botanic Gardens in summer, while there was smaller number of participants in winter with an average of 46 people. At the Botanic Gardens, the

highest levels of participation in other types of activities were recorded on Sunday at an area near Armagh Footbridge. Likewise, playground and picnicking areas appeared to be crowded on that particular day.

Other types of activities included:

- Watching fish, watching/feeding ducks or birds.
- Picnicking, sitting, lying, taking photos and doing exercises.
- Kid biking, skating and riding motorbikes.
- Watching people doing activities.
- Supervising activities.
- Playing flying plates, power car toys, basketball, playing at playground.

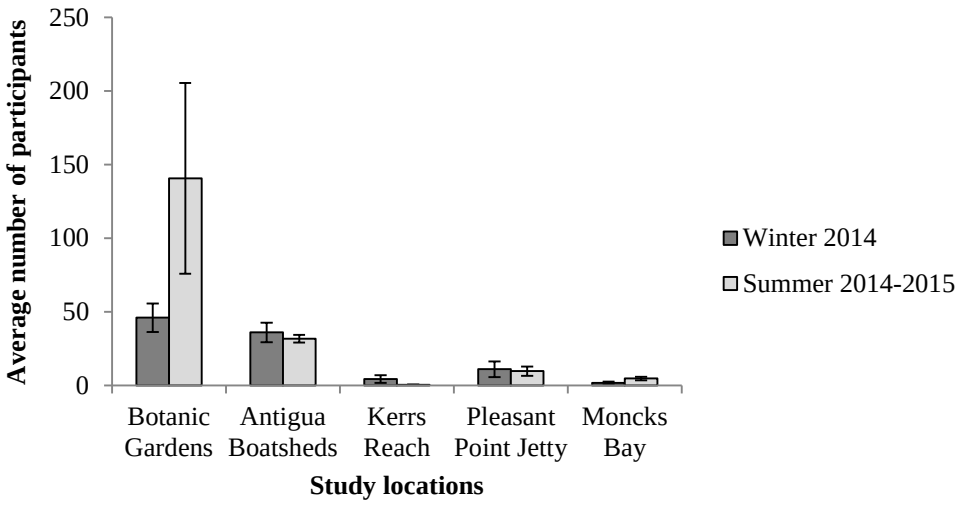


Figure 3.9 Levels of public participation in other activities in winter 2014 and summer 2014-2015.

3.4 Discussion

The earthquakes in Christchurch in 2010 and 2011 severely damaged the city's infrastructure, but 2 years post-quake participation in recreational activities remains high.

This might be because residents have a strong attachment with local recreational areas and desire to be part of its restoration as a place of sport and recreation (T. Williams & Mackay, 2013). This investigation contributes to a deeper understanding of recreational patterns in the river and the Estuary.

Overall, weekends had greater levels of participation in recreation than weekdays at all locations. This similar finding was also reported by Boden and Ovington (1973) and Sasidharan et al. (2005) Who also found that visitation was related to gender, age and income. Females and elders tended to visit on weekdays and people with higher income mainly presented at recreational areas on weekends. In the present study, female and senior participation was smaller than participation of males and younger age groups.

Season impacted levels of participation by individuals and groups at the river and the Estuary. Both individual and group participation rates in summer were substantially higher than winter, and larger levels of group participation in recreation occurred in both seasons. Because temperatures in winter were cold and rainfall sometimes occurred, this resulted in low attendance in most study locations. In contrast, greater participation was recorded in summer when there was warm weather and more sunlight. This was similar to Boden and Ovington (1973) who noted that weather conditions have contributed to variations in recreational use within a season. Visits to recreational areas declined mostly because of rainfall events. Also, attendance for most days appeared closely associated with temperature.

People undertaking recreational activities close to the waterways in Christchurch often did so in groups. According to Sasidharan et al. (2005) and Sessoms (1963), high levels of group oriented activities have previously been associated with social activities, team activities and family centered activities and ethnicity. However, females were less likely

to get involved in team activities, but they tended to participate in park-based community activities. Also, low attendance in team activities, social activities and food-related activities was found among older people (Sasidharan et al., 2005). In the present study, there was group participation at all study areas for several activities such as sightseeing, sailing, rowing, kayaking, fishing, standup paddle boarding, picnicking, feeding/watching animals and playing at playground. Clearly, these activities were related to social activities, team activities and family centered activities. Sasidharan et al. (2005) suggested that the management of recreation resource of parks and forests should take measures to facilitate larger groups for long duration of time, particularly during weekends.

In the present study, female and male participation in recreation increased in summer compared with winter, but there was higher participation by males than females. This result contrasts with Hong (2001) who showed that differences between males and females were not significant in the total level of recreational participation among Korean adults (18 and above) who lived in New Mexico.

In the present study, adults participated in recreational activities more than children, teens and seniors. Season was not a factor influencing levels of participation in recreation among all age groups. The age information collected in the present study was unable to produce an analysis of age groups in association with specific activities. Nevertheless, there were a few activities where participation was from a certain age group. For example, teenagers mostly participated in sailing at Moncks Bay. According to Sessoms (1963), the type of recreation in which an individual participates in was related to age; more passive activities were undertaken as people age. Older people attempted to avoid fairly active outdoor recreation activities. It was also noted that

having children limited vacation travel and increased family-centered activities such as picnicking and riding for pleasure (Sessoms, 1963). In Verhoven' (1977), it was found that recreational patterns of elderly were similar to other groups in the society (as cited in Singleton, 1984). A fewer vigorous activities were undertaken by the elderly compared to the non-elderly (Singleton, 1984).

Accessibility has had a strong effect on recreational activities in the Christchurch area. The current access to all locations allows the public to use the locations for various recreational activities, but organized and supervised activities were rarely observed. Before the 22nd February earthquake, South New Brighton Park was among the most popular places at the Estuary and was also one of the most prevalent entry points to the Estuary (Crawford & Fountain, 2010; Greenaway, 2007). Observations from the present study found that levels of participation in several activities at this location were low. This was probably due to the major influence of the earthquakes to the main entry point for vehicles to this part of the Estuary (Bridge Street Bridge) that would result in smaller numbers using the area (T. Williams & Mackay, 2013).

In order to attract more residents to participate in outdoor recreational activities, more supervision, equipment and organized activities might be required (Sallis et al., 2003). Also, special events may be needed to stimulate recreational participation of population that were under represented users of the locations, consisting of children, teens and seniors (Henderson & Ainsworth, 2001; Hoehner et al., 2005; Sallis et al., 2003). This aspect is particularly important for Kerrs Reach and Pleasant Point Jetty. In 2013, Transitional Community Center and Pleasant Point Yacht Club were relocated to South New Brighton Park. The relocation of facilities and the arrangement of activities by the community and the yacht club have created incentives for residents to visit the location,

and this has also encouraged levels of recreational participation at the location. Pleasant Point Yacht Club has created 2014/2015 Sailing Program in which events are usually organized during high tide on weekends (Photo 9 Appendix 8). Visitors are also offered opportunities to attend any club events. For example, Pleasant Point Yacht Club held Volvo National Sailing Day on Saturday 31st January 2015. Apparently, the event captured a great attention from the public because they were provided chances to try sailing in a diversity of yachts involving the Sunbursts and Sigrid Trailer yachts (Yachting New Zealand, 2015). This successfully organized event has been proved to be a key contributor for increasing level of participation in recreation at this location.

In the present study, participation rates in most recreational activities were lower in winter than in summer. According to Boden and Ovington (1973), numerous recreational studies were investigated on an annual basic and insufficiently illustrated seasonal, weekly and daily variations which were associated with influential climate and contemporary social patterns. Boden and Ovington (1973) found that the ratios of summer to winter use for recreational areas greatly altered. The ratio had a propensity to be large where the key activity is swimming, while it was low where the key interests are picnicking and sightseeing. In the present research, participation in summer was significantly higher than winter where the main activities were walking/sightseeing, biking, boating, swimming and other activities, while attendance in summer was slightly larger than winter where the key activity was running.

Location rather than season appeared to be a significant factor influencing recreational pursuits. In Christchurch, most recreational activities were recorded at the Botanic Gardens and Antigua Boatsheds. These activities involved walking, running, biking, boating, sightseeing, watching/feeding animals, picnicking and playing at playground.

These locations present high values of key drivers underlying visitation of recreational areas noted by Madsen (2011) including proximity to their residences, available facilities, suitability for family outings, scenery, a feeling of seclusion or relaxation, and activities specific to the location. He suggested that the local population was likely to visit municipal recreation locations, and this is true in the present study for the Botanic Gardens and Antigua Boatsheds are located in the inner city of Christchurch. Shafer and Floyd (1997) found that urban parks offer people alternative access routes to shops or work. In the present study, people visiting the Botanic Gardens and Antigua Boatsheds include those commuting from work by walking and cycling along the river.

The Botanic Gardens are connected with Hagley Park and Antigua Boatsheds where public participation in recreation in these areas is usually high. Some of walkers and runners recorded at the Botanic Gardens were probably those who walked from Hagley Park and Antigua Boatsheds. Furthermore, recreationists who walked with their dogs were only allowed to walk along the outer tracks of the gardens along the river instead of the inner footpaths within the gardens. On the other hand, biking was prohibited on the inner tracks within the Botanic Gardens because of concern about safety for children. This was likely to be a cause of the low presence of bikers at this location. There was a potential for recreationists to be miscounted when it was observed times of high recreational activities at this location.

Contrasting with the above locations, recreational levels at Moncks Bay were moderate, while there was low recreational numbers at Kerrs Reach and Pleasant Point Jetty. This may be because the recreational resources available at these locations were localised when compared to the Botanic Gardens and Antigua Boatsheds. Facilities and natural resources may have restricted recreational uses at these locations. Low levels of

participation might also be the result of lack of proper tracks, toilets, playgrounds, a feeling of seclusion or relaxation. Nonetheless, a few significant activities took places at these locations included sailing, rowing, kayaking and fishing. At Pleasant Point Jetty, a fence was used to confine the entrance of jetty, but visitors could be seen walking and fishing on the Jetty (Photo 7 Appendix 8). Even though services were limited and facilities were primitive, the presence of these activities at these locations suggests that the community values these activities.

In conclusion, the waterways close to Christchurch provide a range of activities for the public and visitors. Recreation opportunities were higher in summer than winter and a range of opportunities was limited in some places because of the lack of facilities. This research suggests a great need for outdoor recreational resources that would facilitate different activities. Thus, the development and management of recreational resources should be planned to serve various users. This might redistribute recreational users from highly occupied locations to other sparsely occupied locations and prevent overuse of greatly utilized locations.

Chapter 4

Evaluation of Recreational Resources

4.1 Introduction

Recreational areas contribute to the development of urban life quality because they provide a broad range of benefits and ecosystem services (Breuste et al., 2013; Burgess, 1988; Konijnendijk et al., 2013). In Christchurch, the Avon River and the Estuary have highly recreational, cultural, natural and landscape values (Environment Canterbury, 2012; Environment Canterbury & Christchurch City Council, 2011). They are venues for various recreational activities, provide habitats for animals and other organisms and contribute to shape, character and identity of the city (Environment Canterbury, 2012; Marsden & Knox, 2008; Winterbourn, 2008).

The water quality of the Avon River influences the value that Christchurch residents place on the river (Environment Canterbury & Christchurch City Council, 2011). For settlers in Christchurch, mahinga kai (seafood gathering) was not the only food source for them provided by the Avon River and the Estuary (Boyd, 2010; McMurtrie & Kennedy, 2012), flounders, eels, whitebait, native trout, ducks, birds, lamprey and pipi were also caught for food all year round (Chirstchurch City Council, 2013; Environment Canterbury & Christchurch City Council, 2011). As a consequence of urban development, plant species, birds, fish and invertebrates were impacted (Environment Canterbury 2001, as cited in Dodson, 2007). The amount of some plants and animals decreased in the river and the Estuary. In-stream habitat and macroinvertebrate communities have been affected by the transformation of forests and wetlands to residential areas (Sponseller et al., 2011).

Since human activities in the catchment have influenced the condition of waterways, those that run into the Estuary are key contributors, impacting the Estuary health (Environment Canterbury & Christchurch City Council, 2011). Stormwater drainage from many different sources runs into the Avon and Heathcote Rivers. They transport many different contaminants including fine sediment, heavy metals, nutrients and organic compounds (Ermens, 2007). Other potential sources, particularly following rainfall, include dog faeces and sewage overflows or leakage from damaged sewerage pipes. These also cause potential for human health effects (Moriarty et al., 2013).

From 1999, the management of waterways by CCC broadened to support local ecology, landscape, recreation, heritage, culture and drainage (Environment Canterbury & Christchurch City Council, 2011). An increase in water demand has brought about recognition of the necessity to limit the amount of water utilised by human since water is a finite resource. Subsequently, some Christchurch waterways that had wooden sided drains have initially been reshaped and restored to a more nature-like condition by making the streams wider. A few underground drains were also opened up to be exposed to light. Native plants have later been planted on the banks of streams and rivers in order to provide shade and shelter for fish and invertebrates and to assist in keeping the water cooler and cleaner. All of these works not only enhanced water quality and habitat for the plants and animals, but also created interesting landscape feature of parks and riverside for people to enjoy (Environment Canterbury & Christchurch City Council, 2011). Environment Canterbury has conducted regular monitoring of the recreational water quality at locations in rivers and the estuary over the summer.

As the prevalence of outdoor recreation rises, more public resources are required to support recreational activities (Sessoms, 1963). Numerous studies have been carried out

to examine the supply side of recreational areas such as park size, maintenance conditions, proximity and safety (Cohen et al., 2010; Giles-Corti et al., 2005; Kaczynski et al., 2008; Loukaitou-Sideris, 1995). Other studies have examined the properties and facilities for recreational uses (Burgess et al., 1988; Gobster, 2002; McCormack et al., 2010; Schroeder & Anderson, 1984). Fuller et al. (2007) and More (1985) examined the perception and values of biotic conditions and abiotic elements of recreational areas. According to Voigt et al. (2014), green spaces in urban areas play a key role in providing recreational services for urban residents.

In order to facilitate planning and management of recreational uses in Christchurch in the future, information is needed on the quality of recreational resources. This was undertaken at 5 locations based on values including water quality, the presence of wildlife, habitats and riparian strip along the river banks and shores of the Estuary, the availability of recreational facilities and infrastructure at each study location. It was predicted that all locations there would be poor water quality. Another hypothesis was that the levels of *E.coli* and *Enterococci* at all locations would exceed the trigger values during rainfall. Also, Moncks Bay would be the only location suitable for contact recreation.

4.2 Methods

The assessment of the quality of recreational resources was conducted within an area of 400 m^2 at each study location (Appendix 1). This area was mapped using Google Earth to capture waterways, spaces of recreational activities, infrastructures and adjacent land use. The information gathered was used to produce a baseline evaluation of recreational resources. The assessment was undertaken during a data collection period of winter 2014 and summer 2014-2015.

4.2.1 Water Quality

Water samples were collected from each study location in the river and the Estuary on the same day (Figure 1.1). This study utilised the same methods used in "The Healthy Estuary and Rivers of the City: Water quality and ecosystem health monitoring programme of Ihutai" undertaken by Christchurch City Council (CCC) and Environment Canterbury (Ecan) (Environment Canterbury, 2009). To determine if water quality is suitable for contact recreation, water samples were analysed for the concentrations of *E.coli* in freshwater and the concentrations of *Enterococci* in sea water (Health Christchurch, 2011; Ministry for the Environment, 2003).

River water samples (from the Botanic Gardens, Antigua Boatsheds and Kerrs Reach) and estuary water samples (from Moncks Bay and Pleasant Point Jetty) were tested for a range of water quality parameters (Table 4.1). These are key parameters of concern to water quality for ecological health and contact recreation (Ministry for the Environment, 2003; Whyte 2013). Three water samples were collected from each location in winter and summer. Samples were collected at the beginning and the end of the period of collecting data in each season and also after rainfall events. However, Pleasant Point Jetty was not sampled in winter because water quality data was available from Environment Canterbury. Sampling details are presented in Table 4.1.

The sampling times for the river locations were selected during daylight, but the estuary locations were sampled according to the state of the tide. This was because water quality and recreational activities may be affected by discharges of treated wastewater into the Estuary. Additionally, water-based activities such as kite surfing, wind surfing, kayaking and yachting take place at high tide, whereas some activities such as bird watching and bait collecting occur on mudflats at low tide (Bartram, 2013).

Field measurements at each location included water temperature, Dissolved Oxygen (DO), Dissolved Oxygen saturation, pH, conductivity and turbidity. Some water samples were transported to Hills Laboratories for analysis of Ammmonia Nitrogen (NH_3N), Nitrate-nitrite Nitrogen (NNN), *E.coli* and *Enterococci*, whereas some were tested at the university laboratory. According to Standard Methods for the Examination of Water and Wastewater (Clesceri et al., 1999), Bochemical Oxygen Demand (BOD), Dissolved Reactive Phosphorus (DRP) and Total Suspended Solids (TSS) were measured by 5-Day BOD Test, Ascorbic Acid Method and Total Suspended Solids Dried at 103°C-105°C respectively. Determination of organic compounds was undertaken using Dry Ashing Procedures at 500°C-600^{o}C (McClements, 2003). Salinity was analysed by using a refractrometer.

Table 4.1 Sampling details – water quality parameters, sampling locations, sample types and sampling dates.

<table>
<tr><th rowspan="2">Water quality parameters</th><th rowspan="2">Sampling locations</th><th rowspan="2">Sample types</th><th colspan="2">Sampling dates</th></tr>
<tr><th>Winter 2014</th><th>Summer 2014-2015</th></tr>
<tr><td rowspan="3">DO saturation, BOD, TSS, turbidity, NH_3N, NNN, DRP, salinity and E.coli</td><td>The Botanic Gardens (BG)</td><td>Fresh water</td><td rowspan="4">-16/07/2014*
-04/08/2014*
-27/08/2014*</td><td rowspan="4">-19/11/2014*
-09/12/2014*
-29/12/2014*</td></tr>
<tr><td>Antigua Boatsheds (AB)</td><td>Fresh water</td></tr>
<tr><td>Kerrs Reach (KR)</td><td>Fresh water</td></tr>
<tr><td>DO saturation, BOD, TSS, turbidity, NH_3N, NNN, DRP, salinity, E.coli and Enterococci</td><td>Moncks Bay (MB)</td><td>Sea water</td></tr>
<tr><td></td><td>Pleasant Point Jetty (PPJ)</td><td>Fresh and sea water</td><td>-16/07/2014**
-15/08/2014**</td><td>-19/11/2014*
-09/12/2014*
-29/12/2014*</td></tr>
</table>

* Own assessment of water quality.
** Monthly water quality data from Environment Canterbury.

4.2.2 Habitat Assessment

Habitat evaluations had not been undertaken for the locations selected for this study. The approach called Stream Habitat Walk (United States Environmental Protection Agency, 1997) (Appendix 9) was used for identifying and assessing the elements of a stream's habitat within 400 m^2 of each location (Appendix 1). However, Stream Habitat Assessment Protocols for wadeable rivers and streams of New Zealand (J. S. Harding et al., 2009) was not utilized for this research. The Protocols and the approach were reviewed and compared before selecting a method used for evaluating stream habitat.

Protocol 1 has been designed to provide a quick characterization of a location, but it does not provide sufficient data to assess the stream habitat. Protocol 2 was developed to provide a semi-quantitative assessment of a location with some intensity of measurements and more emphasis on visual estimates. This Protocol is most suitable for State of the Environment monitoring (SOE), consent monitoring, Assessment of Environmental Effects (AEE) and long-term trend monitoring. It requires Desktop GIS protocol together with an assessment of in-stream hydrology and morphology, in-stream physical habitat and riparian habitat. Protocol 2 also needs equipment calibration and the calculation of biological meaningful metrics. It takes 45-60 minutes in the field to complete the measurement (J. S. Harding et al., 2009). It was, therefore, concluded that Protocol 2 was time consuming and costly, and requires rigorous measurements and more complex of data analysis.

In contrast, the Stream Habitat Walk has become popular in many programs that focus on citizen involvement and public awareness. It provides ease of use, adaptability and low cost (United States Environmental Protection Agency, 1997). It was considered that this approach is more suitable for the assessment of habitat in urban waterways and involves visual observations of stream habitat characteristics, wildlife presence and gross physical attributes. In the present study, a simple in-stream invertebrate evaluation was also carried out. Additionally, the habitat variables used in this approach are identical to Protocol 1, but it integrates more precise estimates. Even if this approach is localized by the subjective and categorical assessment of some habitat parameters, it involves macro invertebrate survey and visual biological survey that represents a crucial value of recreation. Hence, the Stream Habitat Walk was chosen for this research.

The evaluation of habitat was undertaken from 28th July 2014 to 19th September 2014 and from 15th December 2014 to 7th January 2015 in summer. At river locations, the Stream Habitat Walk was carried out in every 100 m lengths alongside the river, and it took approximately 20 minutes to accomplish the assessment. It took longer at a few locations that had a longer reach. At Pleasant Point Jetty and Moncks Bay, the evaluation of habitat placed at the edge of riparian zone, high tide, mid tide and low tide levels. This was to identify types of animals and plants found in the Estuary. The presence of silt was also noted.

Freshwater invertebrates were collected from the streambed using a triangular kick net. Sampling occurred in riffles, pool habitats and vegetation. One sample was collected at the edge, 0.5 m and 1 m depth of the river from three sites located upstream to downstream at each location. For some locations, the water was shallow, especially the Botanic Gardens and Antigua Boatsheds, so organisms were collected from 0.75 m depth instead of 1 m. General types and the abundance of invertebrates were initially recorded on the field data sheet before delivering samples for further examination at a lab. Subsequently, samples were kept in a refrigerator at 3-7°C for no longer than 3 days, and invertebrates were preserved with 70% alcohol (ethanol). The sampling period in the winter was extended to complete resource evaluation due to weather conditions, health issues and the availability of field assistance.

4.2.3 Facilities and Infrastructure

Within each study location, field observations were undertaken to identify the available facilities and infrastructures including footpaths, bridges, bus stops, roads, parking areas, playground, buildings, toilets, lights, benches, picnic tables and rubbish bins. The research collected information on quantity and the distribution of those facilities and

infrastructures within defined areas at all locations. The observations were carried out on the same days when conducting habitat assessments.

4.2.4 Data Analysis

Water quality parameters for each location (except for Pleasant Point Jetty) were summarized by the mean of 6 samples collected in winter 2014 and summer 2014-2015. For Pleasant Point Jetty, there were 5 samples. Results were compared between locations and with guidelines provided by the ANZECC (2000) water quality guidelines, Canterbury Natural Resources Regional Plan (2011) (NRRP), Proposed Canterbury Land and Water Regional Plan (2012) (pCLWRP), Resource Management Act (1991) (RMA) Schedule 3 and the New Zealand Microbiological Water Quality Guidelines for Marine and Freshwater Recreational Areas (Ministry for the Environment, 2003) . Furthermore, data collected for habitat assessments were entered in spreadsheet and summarized key findings in a description. Freshwater and marine invertebrates were indentified based on a few sources (Jones et al., 2005; Landcare Research, 2014; Taranaki Regional Council, 2009). Freshwater invertebrate data were summarized utilizing the invertebrate metrics of taxa richness and MCI scores. Scores for hard-bedded (stony) rivers were applied to the Botanic Gardens and Antigua Boatsheds, while scores for soft-bedded (weedy or silty) rivers were applied to Kerrs Reach (Maxted & Stark, 2007; Stark, 1985).

4.3 Results

Field work at a few locations was restricted by road and bridge constructions and the presence of numerous recreational users in a few occasions. Nonetheless, data gathered in both seasons were satisfactory to bring about efficient assessment of recreational resources at each location.

4.3.1 Water Quality

Water temperature

The temperature range was 6.3°C-11.9°C in winter and 14.8°C-21.5°C in summer. Variation of temperatures at most locations in both seasons were below the AZNECC (2000) trigger value of less than 20°C. There was one occasion where the temperature at Pleasant Point Jetty exceeded the trigger value with a rise to 21.5°C on the last sampling round in summer (Figure 4.1). The median temperatures at river locations were similar at 13.5°C-13.7°C, while the median temperatures at Estuary locations were 16°C at Pleasant Point Jetty and 12.5°C at Moncks Bay.

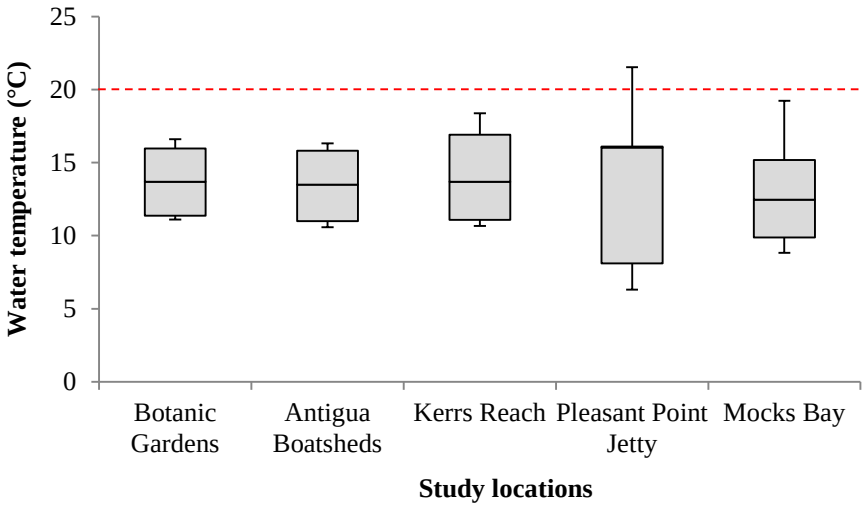


Figure 4.1 Water temperatures (°C) at all locations in winter and summer 2014.

Dissolved Oxygen Saturation

The range of dissolved oxygen saturation was 77.6%-103.5% in winter and 96.4%-155.3% in summer. All median DO saturation results at all locations were suitable for aquatic organisms because the measurements were higher than the trigger value provided by the Resource Management Act guideline of 80% saturation (Figure 4.2). Kerrs Reach had

both the highest DO concentration of 155.2% in summer and the lowest percent saturation of 77.5% in winter. This was below the trigger value by a small percentage.

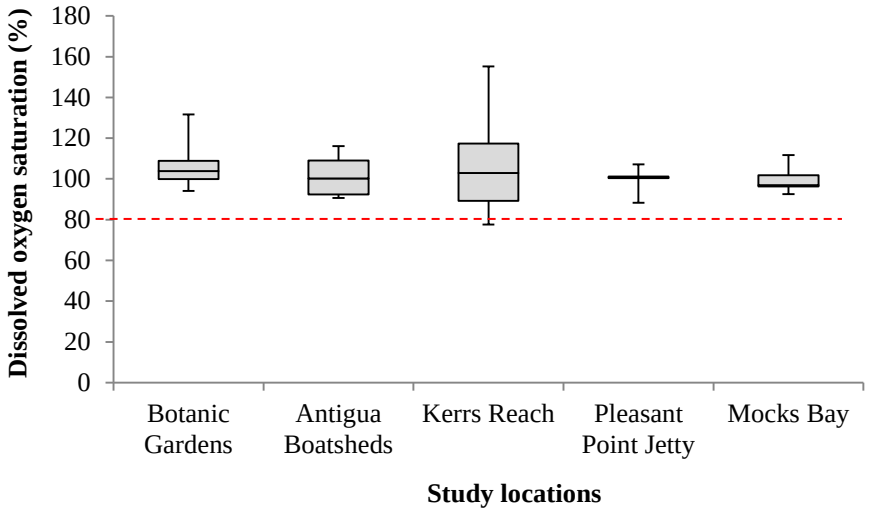


Figure 4.2 Dissolved oxygen saturation (percentage) at all locations in winter and summer 2014.

Biochemical Oxygen Demand (BOD_5)

In winter, BOD_5 levels were 0.30 mg/L-2.24 mg/L, while it was 0.65 mg/L-3.68 mg/L in summer. The median values of BOD_5 at all locations were less than the trigger value. The New Zealand Ministry for the Environment (1992) offered a trigger value for BOD_5 of 2 mg/L. This is higher limit value. BOD_5 results of greater than 2 mg/L occasionally occurred at all locations except for Antigua Boatsheds. The highest BOD_5 level of 3.68 mg/L was detected at Kerrs Reach, followed by 3.38 mg/L at the Botanic Gardens.

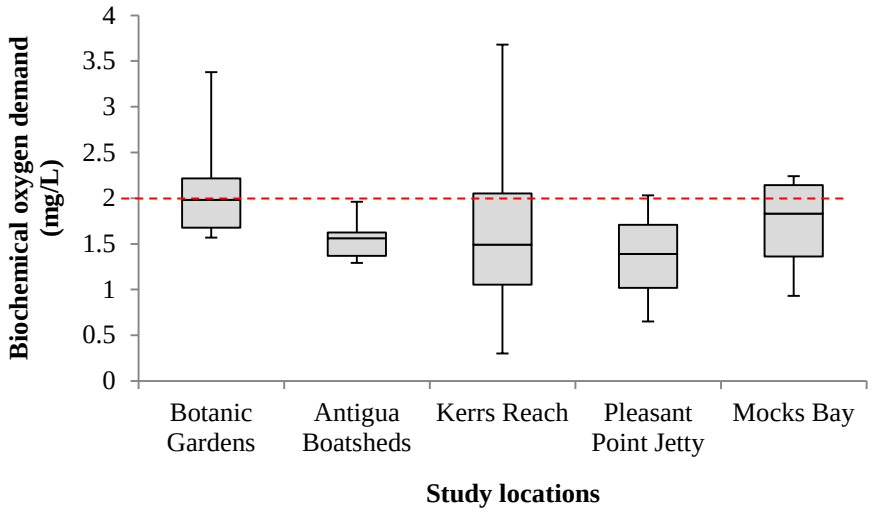


Figure 4.3 Biochemical oxygen demand concentrations (mg/L) at all locations in winter and summer 2014.

Total Suspended Solids (TSS)

The concentrations of TSS at all locations ranged from 0.001 mg/L-0.025 mg/L in winter and from 0.001 mg/L-0.063 mg/L in summer (Table 4.2). Levels of TSS at all river locations were less than Estuary locations. For the measurement of TSS, there was only one water sample collected from each location in winter and summer. Kerrs Reach had the least TSS value of 0.001 mg/L, while Pleasant Point Jetty had TSS level up to 0.063 mg/L. Also, samples were analysed for the percentage of inorganic materials presented in the water. The water at all locations contained almost 100% of inorganic matter per litre (Table 4.3), which it indicated that concentration of organic materials was very low.

Table 4.2 Total suspended solids concentrations (mg/L) at all locations in winter and summer 2014.

Date sampled	Botanic Gardens	Antigua Boatsheds	Kerrs Reach	Pleasant Point Jetty	Moncks Bay
Sep-2014	0.001	0.001	0.001	0.024	0.025
Nov-2014	0.002	0.006	0.001	0.063	0.026

Table 4.3 Inorganic matter (percentage) at all locations in winter and summer 2014.

Date sampled	Botanic Gardens	Antigua Boatsheds	Kerrs Reach	Pleasant Point Jetty	Moncks Bay
Sep-2014	99.98	99.98	99.98	99.97	99.96
Nov-2015	99.99	99.99	99.99	99.95	99.93

Turbidity

Turbidity levels were generally low, but values for Pleasant Point Jetty were varied (Figure 4.4). The results were compared to the AZNECC (2000) guideline of 5.6 NTU (nephelometric turbidity units). Turbidity levels of higher than the trigger value occurred at all locations on the first sampling occasion carried out after rainfall events in winter. Median measurements of turbidity were less than the trigger value at all locations other than Pleasant Point Jetty. The range of turbidity concentrations at Pleasant Point Jetty was much greater than all other locations because it was a tide-influenced location. On two sampling occasions at Pleasant Point Jetty, a peak turbidity value of 119 NTU was observed, followed by 37 NTU.

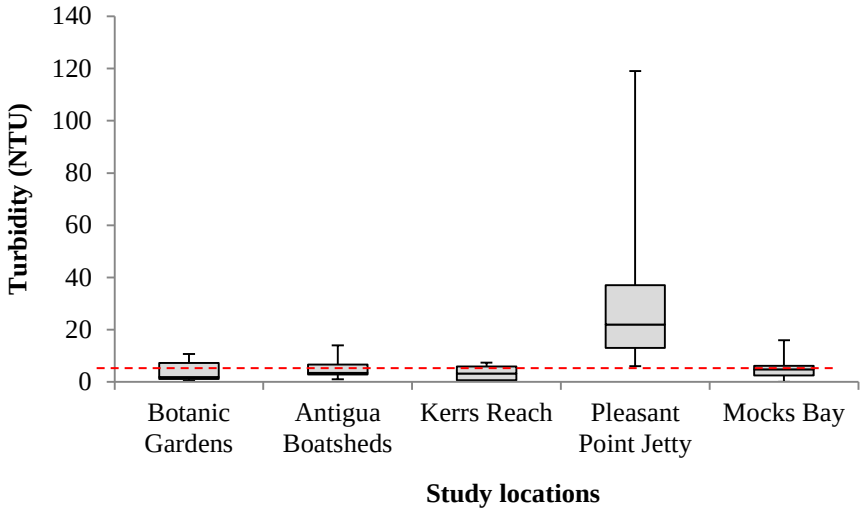


Figure 4.4 Turbidity measurements (NTU) at all locations in winter and summer 2014.

Salinity

It was observed that river locations had median salinity ranging from 1.84 ppt-2.17 ppt (Figure 4.5). At high tide, the salinity at Pleasant Point Jetty and Moncks Bay ranged from 24.3 ppt-32 ppt (parts per thousand) and 32 ppt-38 ppt respectively.

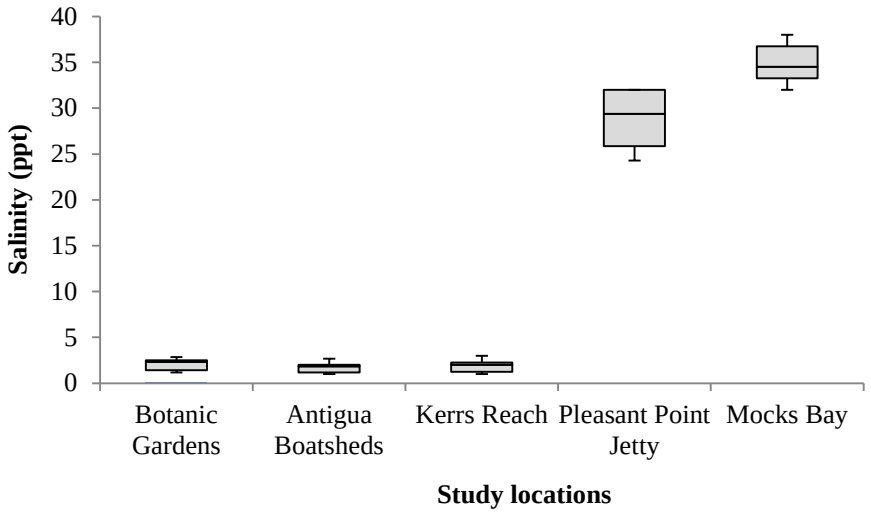


Figure 4.5 Salinity measurements (ppt) at all locations in winter and summer 2014.

Ammonia-nitrogen (NH_3N)

NH_3N levels were 0.022 mg/L-0.104 mg/L in winter and 0.011 mg/L-0.027 mg/L in summer (Figure 4.6). The AZNECC (2000) toxicity trigger value at pH 8 for NH_3N for 95% species protection is 0.91 mg/L. This trigger value is used to assess the potential for the level to be toxic to aquatic life in freshwater and marine water. All measurements of NH_3N at all locations were below the trigger value. NH_3N concentrations commonly appeared to be least in upstream locations and increased downstream towards the Estuary. For example, the lowest NH_3N level of 0.011 mg/L occurred at the Botanic Gardens, while the greatest NH_3N result of 0.104 mg/L was observed at Pleasant Point Jetty.

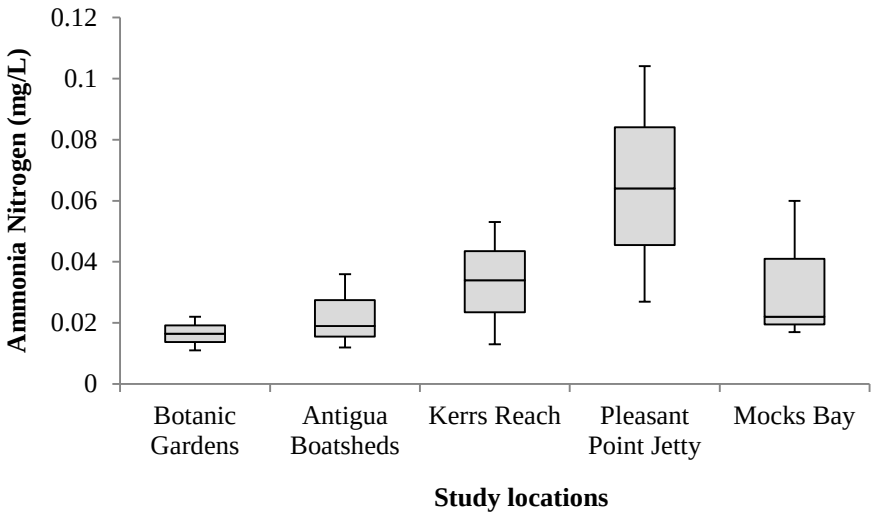


Figure 4.6 Ammonia-nitrogen concentrations (mg/L) at all locations in winter and summer 2014.

Nitrate-Nitrite Nitrogen (NNN)

NNN levels generally appeared to be greatest at upstream locations and declined downstream towards the Estuary (Figure 4.7). The concentrations of NNN of all samples taken from river locations were far above the AZNECC (2000) trigger value of 0.444 mg/L provided for lowland rivers, while NNN levels of most samples taken from Estuary locations were less than this value. The highest NNN concentration of 2.5 mg/L was detected at the Botanic Gardens.

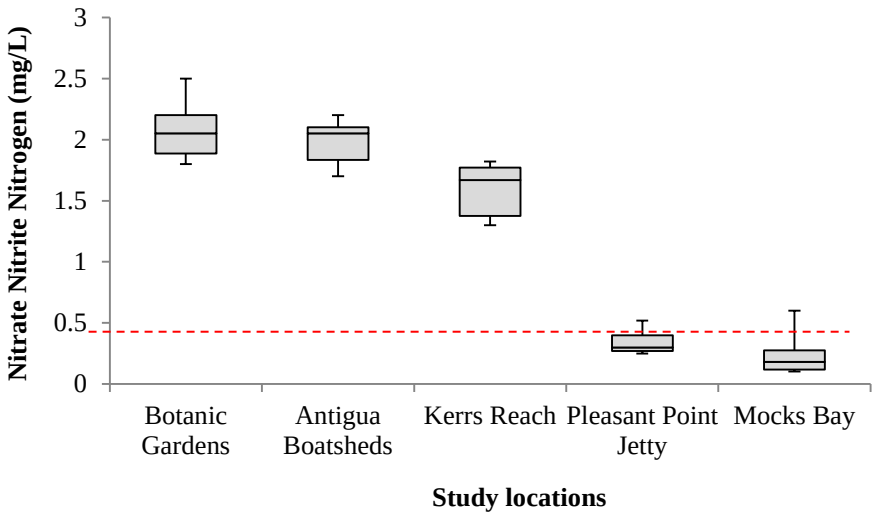


Figure 4.7 Nitrate-nitrite nitrogen concentrations (mg/L) at all locations in winter and summer 2014.

Dissolved Reactive Phosphorus (DRP)

DRP concentrations appeared to be least at upstream locations and escalated downstream towards the Estuary (Figure 4.8). One irregularity to this pattern occurred at the Botanic Gardens which concentrations were much higher than Antigua Boatsheds. However, the median concentrations of DRP at these two locations were below the NRRP (2011) and pLWRP (2012) trigger value of 0.016 mg/L provided for spring fed plains urban rivers. Median levels of DRP at all other locations exceeded the trigger value. The greatest concentration of DRP of 0.207 mg/L was found at Moncks Bay.

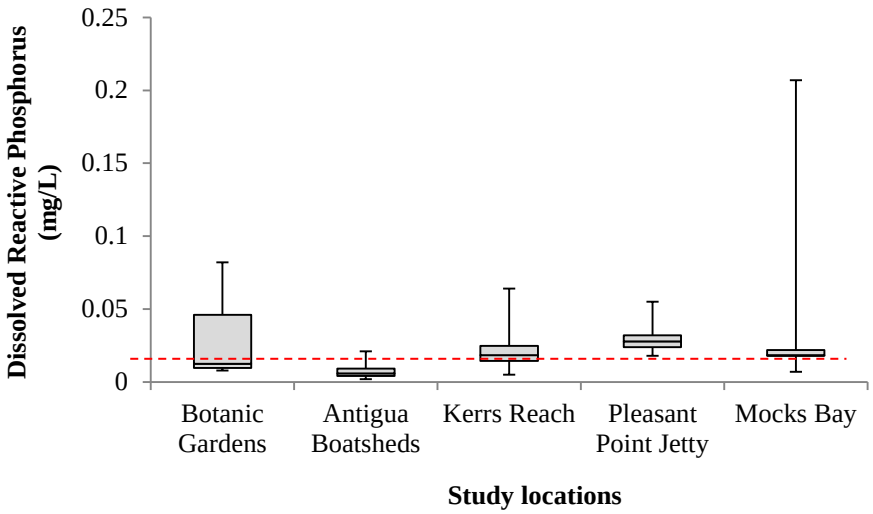


Figure 4.8 Dissolved reactive phosphorus concentrations (mg/L) at all locations in winter and summer 2014.

Escherichia coli (E.coli)

The levels of *E.coli* were greatest at upstream locations and declined downstream towards the Estuary (Figure 4.9). The New Zealand Ministry for the Environment (2003) provided an alert trigger value of 260/100 mL and an action trigger value of 550/100 mL for *E.coli*. All median *E.coli* results at all locations were below these trigger values.

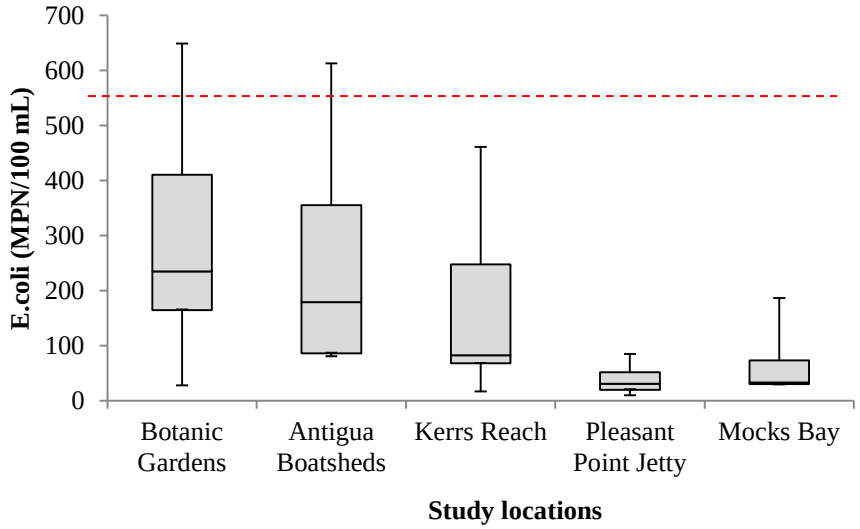


Figure 4.9 *Escherichia coli* concentrations (MPN/100 mL) at all locations in winter and summer 2014.

The majority of *E.coli* measurements at all locations were below the alert and action trigger values (Table 4.4). River locations had concentrations of *E.coli* above these trigger values on a few sampling occasions, whereas Estuary locations commonly had concentrations of *E.coli* much lower the alert trigger value. The first measurement carried out after rainfall events indicated that Antigua Boatsheds and Kerrs Reach had *E.coli* concentrations higher than the alert trigger value. Furthermore, the concentrations of *E.coli* at the Botanic Gardens and Antigua Boatsheds significantly exceeded the action trigger value on the last sampling occasion in summer.

Table 4.4 Detailed *Escherichia coli* concentrations (MPN/100 mL) at all locations in winter and summer 2014.

Date sampled	Botanic Gardens	Antigua Boatsheds	Kerrs Reach	Pleasant Point Jetty	Moncks Bay
16-Jul-14	260	387	461	52	30
4-Aug-14	210	99	<10	-	36
27-Aug-14	461	82	68	20	187
19-Nov-14	28	81	17	10	<10
9-Dec-14	150	260	83	85	31
29-Dec-14	649	613	248	31	<10

* Values highlighted in light grey are above the alert trigger value.
Values highlighted in dark grey are above the action trigger value.

Enterococci

The majority of *Enterococci* values at all Estuary locations were under detected limit (Table 4.5). Ministry for the Environment (2003) provided the alert trigger value of 140/100 mL and the action trigger value of 280/100 mL for *Enterococci*. The highest *Enterococci* level was found at Moncks Bay, which was 31 MPN/100 mL.

Table 4.5 Detailed *Enterococci* concentrations (MPN/100 mL) at all locations in winter and summer 2014.

Date sampled	Pleasant Point Jetty	Moncks Bay
16-Jul-14	<10	10
4-Aug-14	-	<10
27-Aug-14	10	31
19-Nov-14	<10	<10
9-Dec-14	<10	<10
29-Dec-14	<10	<10

4.3.2 Habitat Assessment

The Botanic Gardens

The 1,028 m habitat along the river was the longest section compared to all other study locations. It was surrounded by 125,142 m^2 of green space at the Botanic Gardens and Hagley Park. Generally, the riverbed was made up of sand and gravel, and there were few cobbles. The embeddedness—the extent to which rocks (gravel, cobbles and boulders) are covered by silt and fine sediment—was 25%. Substrates were lightly covered by green algae. A lot of organic materials were present along the river margins close to the bridges and big trees on the river banks. There was a high cover of aquatic plants in the centre of the river and along the river margins.

The river channel at this location had a mean width of 6.6 m. The channel was deep, but the middle section was shallow. It had mostly running water with little pools that appeared near the bridges. The depth of runs and pools were estimated at 0.3 m-0.6 m and over 0.6 m respectively. The levels of water slightly decreased in summer compared to winter. The mean river velocity was 1.25 m/s. The water at all study locations was normally transparent and odourless, but it could be turbid sometimes.

Generally, both left and right banks were steeply sloping. Modification of the left bank occurred more than 50%, created by woods, cement blocks, boulders and cobbles (Photo 8 Appendix 8). The left bank was slightly eroded in the lowest downstream section. It had plentiful lawn areas, some trees, bushes, shrubs and a few ferns on the left bank. In front of the new Visitor Centre, improvements have been made to the left bank by planting new vegetation and making it more stable. The bank had a small area of bare soil where it was mainly covered by leaves in winter. Overhanging vegetation was commonly found on the left river edge of the highest upstream and lowest downstream sections, while just a little was present in the middle section. From the top of the left bank extending to 23 m, there were mostly lawn areas, unpaved tracks, some trees, bushes, a few ferns and some buildings. There were 5 pipes entering the river from the gardens, and a large one was actively discharging from the highest upstream section.

In addition, the right bank was modified by 50% from the Armagh Footbridge. This modification consisted of cement blocks, cobbles and woods. Erosion appeared more on right bank in the highest upstream section, but it was not a significant problem. The presence of some trees, tall grass, bushes, shrubs, lawn areas, unpaved tracks and a few ferns was observed on the right bank, but bushes dominated the bank in the middle section and more evergreen trees were found in the lowest downstream section. In summer, plenty of pollen covered the right bank and tracks as well as a small area of bare ground in the middle section that used to be covered by leaves in winter. Overhanging vegetation was most commonly found from the middle to the lowest downstream sections. From the top of the right bank extending to 23 m, trees, bushes, car parks, unpaved and paved tracks as well as some vines and lawn areas were commonly found. A few newly planted small trees were on both banks in summer. Vegetation provided about 25% shading in the highest upstream section, 50% shading in the middle and

lowest downstream sections. Ducks were present along most of the river but generally close to the bridges including some fish and an eel. In summer, juvenile fish were also seen. Additionally, a small amount of garbage was found adjacent to and in the river. Three small pipes that were not actively discharging entered the river from the right bank.

Antigua Boatsheds

Antigua Boatsheds had a mixture of habitats along a 528 m length of the river. This part of the river was surrounded by a completely built-up environment of 106,955 m^2 that included commercial and institutional buildings, Christchurch Hospital, commercial development areas, road and bridge constructions. There was a considerable amount of silt, sand, some gravel and cobbles were recently added to create riffles. The embeddedness was 25%. Substrates were lightly covered by green algae. Filamentous algae were occasionally found in middle to the lowest downstream sections. A lot of organic materials had accumulated along the river margins and near the bridges. Plentiful macrophytes were attached in running waters and pools.

The mean width of the river was 5.8 m in which the middle section was narrower than other sections. The channel was shallow, but the highest upstream section was deep. This part of the river had a combination of running waters, riffles and a little of pools that occurred close to the bridges. The depth of runs and pools were estimated at 0.3m-0.6 m and over 0.6 m respectively. The mean river velocity was 0.95 m/s.

The left bank generally had a gradual slope, while much of the right bank was steeply sloping. The left bank was modified by over 75% for supporting Curator House, the café, the boatsheds, decking for boats, boardwalks, and flood damage repairs were also undertaken during September. There were many trees, some planted gardens, tall grass,

ferns, lawn areas, cobbles, a little overhanging vegetation and little bare ground on the left bank. Fresh, plain banks were created on both sides of the river from riffles towards the downstream. From the top of the left bank out to 23 m, large lawn areas, some trees, paved and unpaved tracks and car parks were observed. There was no pipe entering the river from the left bank.

The right bank was 25% modified. Erosion occurred in the lowest downstream section more than other sections. Much tall grass, lawn areas, some bushes, shrubs and trees were present on the bank where tall grass grew excessively in summer. The majority of the right bank had overhanging vegetation. From the top of the right bank extending to 23 m, it was common to see paved roads, paved tracks and buildings. The river was shaded by 25% in the uppermost stream section, 50% in the middle and most downstream sections. Some ducks usually inhabited the river and a large eel was seen in the uppermost stream section in winter. A few whitebait and juvenile fish were found during invertebrate sampling in riffles. There were also a few birds catching whitebait from the banks in riffle waters in winter. Some large fish were seen in deep running waters after riffles and in pools in summer. The right bank had a considerable amount of rubbish and construction particles adjacent to and in the river close to the bridges. There were 2 large pipes that were not actively discharging storm water entering the river from the right bank.

Kerrs Reach

Kerrs Reach is located in the Avon River red zone, and the Kerrs Reach area under evaluation consisted of 124,244 m^2 of land and 471 m of river length. Its surrounding included housing areas, paved roads, road construction and an abandoned sports stadium. Some houses were being repaired, while some were being demolished. Avonside Drive

and Locksley Avenue were two main paved roads adjacent to the river, but they were damaged. Some part of Avonside Drive was flooded after rainfall particularly in winter. The river was deep and wide and dominated by pools. The uppermost stream section along the Avonside Drive was around 8 m wide. From this point, the river became much wider to the most downstream section with an approximate width of 48 m. The estimated depth of pools in most sections was over 1 m. Kerrs Reach had excessive growth of aquatic plants and green algae mostly along the river margins and some algae in pools (Photo 11 Appendix 8). Kerrs Reach also had more pest plants than all other locations. This problem became more critical in summer.

The uppermost stream section was mainly covered by silt, a little gravel and cobbles. The embeddedness was 50%. Along the river margins, organic materials were occasionally found. Both left and right banks had steep slopes and little erosion, but erosion occurred more on the right bank. Less than 25% of the left bank was modified by adding cobbles with mesh with plentiful tall grass and some trees. Very little overhanging vegetation and some pest plants were found on the left river edge. Artificial modification was not made to the right bank. This bank had some trees and was predominantly covered by pest plants and tall grass. The right river edge had some overhanging vegetation. Degradation of natural riverside plants was found on both the left and right banks. Less than 25% of the river was shaded. Some garbage was observed adjacent to and in the river but a large amount of grass waste and more rubbish was found floating in the water in summer (Photo 10 Appendix 8). Also, people set up equipment for catching whitebait in a few sites and some fishing equipment was left in the water and on the banks. There were two small pipes entering the river from the right bank and one from the left bank. None of these pipes were actively discharging water. A few ducks and geese inhabited this part of the river.

In the lowermost region of the section, the riverbed was predominantly covered by silt. The left bank had a steep slope while the right bank was vertical in the middle section and gradually sloping in the lowest downstream section. The left bank was 75% modified with cobbles with mesh. The bank was mainly covered by tall grass and a few trees. Just a small amount of overhanging vegetation was found on the left river edge. Furthermore, the right bank was modified by 75%, consisting of cobbles with mesh and wood. This was slightly eroded downstream. Some parts of the right bank had plentiful tall grass and pest plants while others were dominated by short grass. There were no trees on the right bank. The bank adjacent to rowing club areas was predominantly covered by gravel and cobbles. Along the right river margins was gravel, some cobbles and organic materials that appeared close to slipway and in the lowest downstream section. The river was mostly open with little shade. Also, there was some rubbish, numerous waterfowl and dog faeces occurring on floating pontoons and the downstream right bank. There was little rubbish evident on the left bank. Two small pipes that were not actively discharging entered the river from the right bank. A lot of ducks and geese were commonly found in this part of the river.

Pleasant Point Jetty

This location included Picnic Area E and Picnic Area F. Waterways covered less than half of the location. Some houses were located along Estuary Road. Construction was underway on Bridge Street Bridge. Additionally, access to a part of Picnic Area E to the south was prohibited for clearing land. The ground between a children's playground and the jetty was surrounded by a fence to protect native plants that were newly grown by the CCC but recreationists could still use a track. There were some pine trees giving shade along the tracks close to the shore as well as some native plants. Little rubbish was found

at this location. Along the shore there were still some damage from the earthquake such as uneven ground, gigantic fallen trees; broken tracks, boat ramps and concrete walls; and damaged banks made of stones with mesh. The stones were lightly covered by green algae.

Seagrass, shrubs, salt marsh and jointed wire rush were found at the high tide zone in the area from the jetty to the Bridge Street Bridge. In winter, some dead salt marsh plants living slightly above the high tide zone were observed. The high tide zone had sandy sediment and some small stones. Some green seaweed was seen in winter but it dominated the top of this zone in summer (Photo 12 Appendix 8). In high and mid tide areas, the mudflats were mainly stable but there were a few muddier parts in the mid tide zone. An anoxic layer of around 1-2 cm with compact sand occurred in the mid tide area. The mudflats had softer sand in 2-6 cm of the anoxic layer in the low tide zone and the water was noticeably silty and smelly. There were several types of birds found at this location comprising of black swans, royal spoonbills, white-faced herons, red-billed gulls and black-billed gulls.

Moncks Bay

Waterways covered over half the area for resource evaluation within this location while the rest of the area was residential with a few roads. There were only a few plants growing along the Estuary Walk. At this location, the shore had been modified by creating riprap, concrete walls and rocky walls. An outfall pipe was also found. Rubbish was rarely found at this location.

Stones and gravel were found in high tide zone. Black anoxic sediment that occurred after the earthquake settled in this area. There was also a small amount of sea lettuce. In

the mid tide zone there was a rocky habitat in the east part of this location and some small stones and mud in other parts. There was an anoxic layer of less than 1 cm from the sediment surface. Filamentous algae, sea lettuces and red seaweeds occurred at mid tide zone. In the low tide area, there were more sea lettuce and red seaweeds compared to the mid tide area. There was a range of red and brown algae on the slipway (Photo 13 Appendix 8). In the low tide zone, there was an anoxic layer of 2-8 cm in the sand sediment. In winter, juvenile fish, seagrass debris, organic materials and foam were seen on the water surface in this zone. The water was clear but it had a distinct smell. There were not many types of bird found in this location apart from black-billed gulls and shags.

4.3.3 Freshwater and Marine Benthic Invertebrates

Invertebrates collected from all study locations were evaluated to illustrate the state of health of the waterway. Overall, 46 aquatic invertebrate taxa were found at all study locations in the Avon River (Table 4.7). The number of invertebrates found in winter and summer were very similar. The Botanic Gardens had the greatest number of taxonomic groups (30) inhabiting in the river, while the smallest number of taxonomic groups (26) was found at the Antigua Boatsheds (Table 4.6). Commonly found taxa from these locations comprised of *Physa acuta, Potamopyrgus* sp., *Gyrauluscorinna, Paracalliope fluviatillis,* ostracoda, Oligochaeta, *Orthoclad,, Chironomu* and water mites. A few sensitive caddisflies such as *Pycnocentrodes* sp., *Hudsonema* sp. and *Hydrbiosisdae* inhabited the Botanic Gardens and Antigua Boatsheds. *Physa acuta* and flat worms also dominated these two locations, whereas fewer of them resided at Kerrs Reach. The most abundant taxa at Kerrs Reach were Oligochaeta worms, *Cladocera* and *Gyrauluscorinna*

and water mites. Additionally, MCI scores of the Botanic Gardens, Antigua Boatsheds and Kerrs Reach were around 85, 75 and 61 respectively (Table 4.6).

Table 4.6 Taxonomic richness and MCI scores of all locations in the Avon River.

Study locations	**Botanic Gardens**	**Antigua Boatsheds**	**Kerrs Reach**
Taxonomic richness	30	26	29
MCI	85.28	75.23	61.55

Table 4.7 List of freshwater invertebrates found at locations in the Avon River.

Taxonomic groups	**Botanic Gardens**		**Antigua Boatsheds**		**Kerrs Reach**	
	Winter 2014	Summer 2015	Winter 2014	Summer 2015	Winter 2014	Summer 2015
Caddisflies						
Pycnocentrodes sp.	x	x	x	x	x	
Pycnocentria avecta		x				
Paroxyethira hendersoni					x	x
Hudsonema sp.	x	x	x	x		
Pycnocentrella			x			
Oeconesus		x		x		
Triplectides		x				x
Oxyethira albiceps			x	x		
Polyplectropus puerilis	x	x				

Taxonomic groups (Cont)	Botanic Gardens		Antigua Boatsheds		Kerrs Reach	
	Winter 2014	Summer 2015	Winter 2014	Summer 2015	Winter 2014	Summer 2015
Hydrbiosisdae	x		x	x		
Neurochorema	x					
Psilochorema		x				
Unidentified caddisfly larvae					x	
Sandflies						
Austrosimulium	x					
Damseflies						
Xanthocnemis zealandica	x		x		x	
Ischnura aurora				x		
True flies						
Ceratopogonidae	x					
Empididae			x			
Chrironomus					x	
Paradixa				x		
Podonominae pupa	x	x			x	x
Fly larvae					x	
Beetles						
Dytiscinae larvae		x				x
Bugs						
Sigara		x				x
Springtails						
Collembola						x

Taxonomic groups (Cont)	Botanic Gardens		Antigua Boatsheds		Kerrs Reach	
	Winter 2014	Summer 2015	Winter 2014	Summer 2015	Winter 2014	Summer 2015
Other insects						
Unidentified insect						x
Amphipods						
Paracalliope fluviatillis	x	x	x	x	x	x
Phreatogammarus		x	x	x	x	x
Copepods						
Cyclopoid					x	x
Other crustaceans						
Herpetocypris pascheri	x	x	x	x	x	x
Cladocera					x	x
Water mites	x	x	x	x	x	x
Worms amd worm-like						
Oligochaeta	x	x	x	x	x	x
Orthoclad	x	x	x	x	x	x
Chironomus		x		x	x	x
Chironomid larvae	x				x	
Nothodixa sp.			x			
Tanypodinae		x				
Flatworms						
Cura	x	x	x	x	x	x

Taxonomic groups (Cont)	Botanic Gardens		Antigua Boatsheds		Kerrs Reach	
	Winter 2014	Summer 2015	Winter 2014	Summer 2015	Winter 2014	Summer 2015
Earthworms						
Eiseniella tetraedra			x	x		
Hydra						
Phylum Cnidaria			x			x
Snails and bivalves						
Physa acuta	x	x	x	x	x	x
Gyrauluscorinna		x	x		x	x
Potamopyrgus sp.	x	x	x	x	x	x
Pseudosuccinea			x			
Sphaerium novaezelandiae	x	x	x	x	x	x
Ferrissia	x					
Small coiled snail					x	

At the Estuary locations, there were 48 marine benthic invertebrate taxa found in total in which 24 and 40 taxonomic groups were present at Pleasant Point Jetty and Moncks Bay respectively (Table 4.8). The number of taxa in winter was similar to summer. Common taxa appearing at these locations included *Talorchestia* sp., *Elminius modestus, Chamaesipho columna, Capitella capitata, Terebellid,* tunneling mud crabs, hairy handed crabs, cockles, mudflat whelks and mudflat top shells. Common seaweeds found were sea lettuce, green algae and red algae. Estuarine barnacles were found on hard substrates at Moncks Bay.

In the high tide area of these locations, mud crabs and beach fleas (brown amphipod) were abundant. The predominant animals at mid tide included cockles, native mudflat snails (*Amphibola renata*), crabs and polychaete worms. Cockles and mudflat snails at low tide were larger than those at the mid tide zone. At Moncks Bay, brown and banded periwinkles were mostly found at the high tide zone and both small and large greenshell mussels appeared around the jetty at low tide.

Table 4.8 List of marine benthic invertebrates found at locations in the Avon-Heathcote Estuary.

Taxonomic group	Common name	Pleasant Point Jetty		Moncks Bay	
		Winter 2014	Summer 2015	Winter 2014	Summer 2015
Ligia novaezealandiae	fast-running isopod		x		
Talorchestia sp.	stripy amphipod	x	x	x	
Transorchestia chiliensis	brown amphipod	x			
Austrohelice crassa	tunneling mud crab	x	x	x	x
Hemigrapsus crenulatus	hairy handed crab	x	x		x
Macrophthalmus hirtipes	stalk-eyed mud crab	x	x		
Petrolisthes elongatus	half crab			x	x
Cyclograpsus lavauxi	smooth shore crab			x	
Hymenosomatidae crab					x
Elminius modestus	estuarine barnacle	x	x	x	x
Chamaesipho columna	estuarine barnacle	x	x	x	x
Chiton pelliserpentis	snakeskin chiton			x	x
Austrovenus stutchburyi	Cockle	x	x	x	x
Paphies australis	Pipi				x
Nodilittorina cincta	brown periwinkle			x	x
Nodilittorina antipodum	banded periwinkle			x	x
Buccinulum vittatum	lined whelk			x	
Cominella glandiformis	mudflat whelk	x	x	x	x
Diloma subrostrata	mudflat top shell		x	x	
Amphibola crenata	mudflat snail	x	x		

Taxonomic group (Cont)	Common name	Pleasant Point Jetty		Moncks Bay	
		Winter 2014	Summer 2015	Winter 2014	Summer 2015
Melagraphia aethiops	spotted top shell			x	
Micrelenchus tenebrosus	small topshell				x
Haustrum haustorium	dark rock shell				x
Potamopyrgus estuarinus	small brown snail		x		
Aulacomya ater maoriana	ribbed mussel			x	
Perna canaliculus	greenshell mussel			x	x
Xenostrobus pulex	little balck mussel			x	
Mytilus edulisgalloprovincialis		x			
Tiostrea chilensis lutaria	Oysters			x	x
Lepsiella scobina	oyster borer				x
Cellana ornata	Ornate limpet			x	x
Scutus breviculus	ducksbill limpet			x	
Perinereis nutia	errant polychaete	x		x	
Perinereis novaehollandiae	-				x
Nicon aestuariensis	estuary worm				x
Capitella capitata	very small worms	x		x	
Pectinaria australis	sand worm				x
Orbinia papillosa	tube worm				x
Nereis cricognatha	-	x			
Terebellid	blood worm		x		x
Unidentified tube worm					x

Taxonomic group (Cont)	Common name	Pleasant Point Jetty		Moncks Bay	
		Winter 2014	Summer 2015	Winter 2014	Summer 2015
Anthopleura aureoradiata	mudflat anenome			x	
Juvenile fish				x	
Dead Portugese man-of-war	blue bottle				x
Ulva lactuca	sea lettuce		x	x	x
Enteromorpha spp.	green algae		x	x	
Gracilaria chilensis	red algae		x	x	
Zostera novazelandica	Seagrass		x		
Apodasmia similis	jointed wire rush, oioi		x		
Dead salt marsh plant		x			

4.3.4 Facilities and Infrastructure

The Botanic Gardens

Several facilities and infrastructure supported numerous recreational users at the Botanic Gardens. The new visitor centre was opened in April 2014 and is located upstream of the Avon River banks to the east of the observation area. This multi-purpose building includes a function room, Ilex Café, an exhibition zone and a gift shop. Other buildings included the old visitor centre and old Botanic Gardens Café that was impacted by the earthquake. Within the Botanic Gardens, there were public toilets and a playground that also included a swimming pool opened only in summer. Furthermore, a new unpaved pathway and stairs leading down to the river were constructed close to the new visitor centre in winter and completed in summer 2014. The inner footpaths of the gardens along the river had a mixture of paved and unpaved ground that became wider downstream, whereas the outer tracks were totally unpaved and became narrower downstream. Puddles occurred on unpaved tracks after rainfall. Additionally, a car park connecting the Armagh Footbridge was capable of serving 270 spaces. Another car park connecting with the West Bridge had approximately 100 spaces. Bike parking facilities, lights and a total of 6 trash bins were located in these parking areas and close to these bridges. The location of Tennis, Croquet and Bowls facilities was opposite the West Bridge. To support recreation along the river, 3 picnic tables and 9 benches were found on the right bank while 13 benches were provided on the left bank within the gardens.

Antigua Boatsheds

This location included facilities and infrastructure that had been recently improved. Within “Watermark”, both newly paved and unpaved pathways were created, and

boardwalks along the river bank were also enhanced. There were completely paved tracks along the river on Oxford Terrace. A total of 9 benches were in good condition and found in seating areas, on boardwalks and on both sides of the river banks. Antigua Boatsheds was the only location that had lights installed along the pathways and those were of good quality. There were more than 100 car spaces available in one parking area and along the roads within the location. Two bus stops were found close to the river. Additionally, a café was located beside the boatsheds, the main launching point for watercraft. Two existing bridges were usable but another was under construction to replace the old one that was demolished as a consequence of the earthquake. This location had 4 rubbish bins but no public toilet was available. An upstream section of river bank behind the hospital included 2 benches and a few lights. The location of Curators House was opposite this section of river bank and it also contained walkway, a boardwalk and stairs leading down to the river.

Kerrs Reach

Kerrs Reach had few recreational facilities and infrastructure for public use compared to all other study locations. Buildings located within the observation area belonged to the Avon Rowing Club, the Union Rowing Club and the Canterbury Rowing Club. There were two nearby buildings belonging to Christ's College Rowing Club and the Arawa Canoe Club. There was no public toilet at this location. There were three floating pontoons in front of rowing club buildings available for public use but priority would be first given to rowing and two or more people craft. Also, a fishing restriction included prohibiting white baiting from the pontoons. Two main parking areas could be accessed via the southern entry point from Kerrs Road and Avonside Drive. There were around 69 car parking spaces. Bike parking facilities were found

only within building areas that were not available for public use. The public could also access the location from Locksley Avenue. Shared tracks along both sides of the river were unpaved and few puddles could occur after rainfall. There were 3 benches but there was no table at this location. A single rubbish bin was found on the left bank. At the entry point to the car parks was an information board on the proposed Kerrs Reach Rebuild.

Pleasant Point Jetty

It was found that the Pleasant Point Jetty had limited facilities and infrastructure available for recreation because the earthquake substantially damaged it. Two main car parks at the Pleasant Point Jetty were located in front of Picnic Area F and around the Transitional Community Centre. These car parks contained around 90 parking spaces. A car park near the jetty was damaged. Unpaved tracks along the shore were shared by walkers, runners and cyclists but some parts of the tracks were broken and had small puddles after rainfall. Picnic Area E contained a children's playground, a basketball court, picnic tables, a drinking water tap, an unusable toilet and an unusable barbeque pit. Other facilities included 6 benches, 5 tables and 4 rubbish bins within picnic areas, the playground and along the shore. Some tables and benches were in a somewhat poor condition. Two existing boat ramps were damaged. One was unusable and the other, located in front of Pleasant Point Yacht Club's (PPYC) boatsheds, was still utilized. In summer, the South Brighton Bowls Club building was demolished. An information board on the proposed playground improvement plan was found at the playground.

Moncks Bay

Facilities and infrastructure at this location supported different recreational activities. The Christchurch Yacht Club was located within the observation area. Just one car park of 22 spaces and an area for setting up yachts were both next to the yacht club building. There were no bike parking facilities in the area. A bird watching house was located in the western part of the location. There was one bus stop in front of the bird watching house and one close to the car park entrance. Fishing from the pontoon in front of the yacht club was forbidden. One boat ramp next to the pontoon was available for club members while the public could use another ramp slightly damaged by the earthquake. The Estuary Walkway was created using a combination of mostly unpaved ground, some concrete and wood. Puddles appeared on unpaved tracks after rainfall. Furthermore, there were a total of 11 benches and 3 rubbish bins close to building areas and mainly along the Estuary Walkway. However, there was no table at this location. Recreationists were encouraged to use the public toilets located in Barnett Park, 500 m off Main Road. Signs warning of health risks and stating general boating rules were erected to advise people on safe recreation.

In terms of recreational resources, the Botanic Gardens, Antigua Boatsheds and Moncks Bay have supported activities better than all the other locations. Pleasant Point Jetty has encouraged activities to some extent while Kerrs Reach has supported quite a few activities. This was because there were more earthquake impacts on the resources at Pleasant Point Jetty and Kerrs Reach. The observations of recreational resources, facilities and infrastructure of all locations are summarized in Table 4.9.

Table 4.9 A summary of recreational resources, facilities and infrastructure available at all locations.

Assessment elements	Botanic Gardens	Antigua Boatsheds	Kerrs Reach	Pleasant Point Jetty	Moncks Bay
Green space	- River: 1,028 m long; 6.6 m wide - Mostly green space	- River: 528 m long; 5.8 m wide - Little green space	- River: 471 m long; 8-48 m wide - Little green space	- More than 50% - Large green space	- Less than 50% - Little green space
Water quality	- High BOD_5, DRP, NNN and *E.coli* - Clear and odourless - Turbid on a few occasions - Taxa richness: 30 - MCI scores of 85	- High NNN and *E.coli* - Clear and odourless - Turbid on a few occasions - Taxa richness: 26 - MCI scores of 75	- High BOD_5, DRP, NNN and *E.coli* - Clear and odourless - Turbid on a few occasions - Taxa richness: 29 - MCI scores of 61	- High DRP and turbidity - Low *E.col* and *Enterococci* - Silty and smelly - Taxa richness: 24	- High DRP - Low *E.col* and *Enterococci* - Clear and odourless - A distinct smell - Taxa richness: 40
Bank/shore stability	- Slightly eroded - Over 50% artificial banks	- Slightly eroded - 50% artificial banks	- Slightly eroded - Over 50% artificial banks	- Some erosion - 50% artificial banks with damage	- Stable banks - Over 75% artificial banks
Riparian zone	- 2-7 m vegetated bank width: planted gardens, plentiful lawn, some trees, tall grass, bushes,	- 1.5-6 m vegetated bank width: many trees, some planted gardens, lawn, tall grass, bushes,	- 2 m vegetated width: plentiful tall grass, few trees and short grass, some pest plants on	- Newly grown native plants - Some pine trees giving shade	- A few plants along the Estuary Walk

	shrubs, a few ferns and evergreen trees, little bare ground - 50-75% of overhanging vegetation - Over 75% riparian cover	shrubs, a few ferns and little bare ground - 50% overhanging vegetation - Up to 75% riparian cover	banks and water's edge, some gravel and cobbles - Minimal overhanging vegetation - Up to 75% riparian cover	- Some earthquake damage: uneven ground, a few falling trees, broken tracks, boat ramps and concrete walls	
In-stream conditions/Intertidal and marine zones	- Variety of water depths, pools and runs - Fast flowing water - A lot of organic material along margins and near bridges - High cover of aquatic plants	- Variety of water depths, pools, riffles and runs - Fast flowing water - A lot of organic material along margins and near bridges - High cover of aquatic plants	- Pools over 1 m depth - Slower flow than upstream locations - Some organic material along margins - Prolific growth of aquatic plants and green algae	- Tidal influences - Seagrass, shrubs, salt marshes, jointed wire and green seaweed	- Tidal influences - Little organic materials - Red and brown algae, filamentous algae, sea lettuces, red seaweeds and seagrass debris - Foam on water surface on a few occasions
Sediment on river/estuary bed	- Mostly sand and gravel, few cobbles - Light layer of green algae - 50% shading	- A considerable amount of silt and sand, some gravel and cobbles - Light layer of green algae with some filamentous algae - 50% shading	- Mostly silt, a little gravel and cobbles - Less than 25% shading	- Sandy sediment and some small stones - Anoxic layer 1-6 cm - Stable mudflats in high and mid tide areas - Muddier low tide zone	- Stones, gravel and mud - Earthquake, black anoxic sediment - Anoxic layer 1-8 cm

Wildlife values	- Many ducks, some fish and birds, a few eels	- Many ducks, some fish and birds, a few eels	- Many ducks and geese	- Many types of birds, cockles, mudflat snails, mud crabs	- A few types of birds, a few fish, mud crabs, cockles, pipi, whelks and some mussels
Adjacent land use	- Gardens - Hagley Park - Some buildings and car parks - Lawn areas, paved and unpaved tracks, some trees, evergreen trees, bushes, a few ferns	- Buildings, the hospital, bridge and road constructions - Lawn areas, paved and unpaved tracks, paved roads, a few trees, bushes and ferns	- Housing areas, paved roads (damaged), road construction and an abandonned sport stadium - Some house repairs and demolition	- 2 large picnic areas - Some houses - Construction on Bridge Street Bridge - Land clearing	- Residential zone and a few roads
Amenities	- Large number of amenities - Planted garden - Nice riverscape - Lawn areas - Tranquil - Clean - Little garbage	- Large number of amenities - Planted garden - Nice riverscape - Lawn areas - Tranquil - Clean - A considerable amount of garbage and construction particles	- Low number of amenities - Demolition of houses - Excessive aquatic plants, some pest plants on banks and water's edge - Widespread waterfowl faeces on pontoons and banks	- Moderate number of amenities - Scenic beauty - Picnic areas - Tranquility - Land clearing - Some earthquake damage - Little rubbish	- Large number of amenities - Scenic Beauty - Clean - Rarely found rubbish

			- Some rubbish		
Viewing platforms	- In front of the new visitor centre	- Platform and boardwalks within "Watermark"	- 3 floating pontoons	- The jetty	- 1 floating pontoon
Tracks	- 1-3 m shared tracks including paved and unpaved ground	- 1-2 m shared tracks including paved and unpaved ground	- 1 m shared and unpaved tracks	- 1 m shared and unpaved tracks, some uneven and broken parts	- 1-2m of the Estuary Walkway including unpaved, concrete and wood
Car/bike parking	- 2 parking areas of about 370 spaces - Bike parking facilities	- 1 parking area of over 100 spaces and parking along the roads - Bike parking facilities - 2 bus stops	- 2 parking areas of around 69 spaces and parking along the roads - Bike parking facilities for rowing club members only	- 2 parking areas of about 90 spaces - 1 damaged car park - No bike parking facilities	- Minimal parking with 22 spaces - No bike parking facilities - 2 bus stops
Toilets	- Usable public toilets	- None	- None	- Unusable public toilets	- None
Other facilities and infrastructure	- The new visitor centre - Damaged old visitor centre and café - Playground and a swimming pool - Tennis Croquet Bowls	- Curator House - The Antigua Boatsheds - The café - 2 bridges - 11 benches, 4 rubbish bins, lights, no table	- Rowing club buildings - 3 benches, 1 rubbish bin, no table	- A Transitional Community Centre - PPYC boatsheds - Playground - A basketball court - 2 damaged boat ramps,	- Christchurch Yacht Club building - A small area for setting up yachts - Bird watching house - 2 boat ramps

	- Armagh Footbridge and West Bridge - 3 picnic tables, 22 benches, 6 trash bins, lights			one of them is useable - A drinking water tap and unusable barbeque pit - 5 picnic tables, 6 benches, 4 rubbish bins	- 11 benches, 3 rubbish bins, no table

4.4 Discussion

Christchurch City areas have supported a variety of activities for many years although earthquake activities have limited some activities. An evaluation of the resources indicated that each location has both merits and drawbacks affecting the ecosystem health and services as well as the recreational uses of the river and the Estuary.

The Botanic Gardens and Antigua Boatsheds offered several opportunities for recreationists to enjoy both relaxing and physical activities. Voigt et al. (2014) emphasized that not only the size of recreational areas is crucial for providing a wide range of alternatives of activities and enjoyment but also the diversity of biotic conditions (e.g. trees, forest aspects and ground vegetation), non-biotic features (e.g. water elements and topography) and man-made facilities (e.g. playgrounds, sport areas, benches, toilets, amenities and relaxation facilities). Furthermore, accessibility and tranquility are also important. Water elements are essential, especially when visual dominance of water is present. Both the Botanic Gardens and Antigua Boatsheds provide more green features and space compared to all other locations. The Christchurch City Council promotes the Botanic Gardens as representing the character and identity of the city as the garden city (Christchurch City Council, 2014a). More (1985) pointed out that vegetation types can have an impact on the use of recreational areas. For instance, the presence of grass supports some activities such as reading, playing, sleeping and eating. In the present research, both the Botanic Gardens and Antigua Boatsheds had large trees providing shade for visitors and stream beds that were also shaded by shrubs and grass. These locations were covered by aquatic plants, overhanging vegetation and natural debris that provided food and hiding places for fish and invertebrates. Also, many

different habitats occurred at these locations. Fuller et al. (2007) showed that species richness and habitat diversity had a positive correlation with psychological well-being.

On the other hand, the habitat conditions were not suitable for sensitive aquatic invertebrates although fish and eels appeared at these locations. According to Maxted and Stark (2007) and Stark (1985), "clean water" must have MCI scores over 120; MCI scores of 100 - 119 indicate "possible mild pollution" water; MCI scores of 80 - 99 show "probably moderate pollution" of water; and MCI scores of below 80 indicate "probably severe pollution" of water. It was found that the water quality at the Botanic Gardens was probably moderately polluted with MCI scores of around 85 while the water at Antigua Boatsheds was probably severely polluted with MCI scores of approximately 75. This was similar to Winterbourn (2008) who reported that the water quality of the Avon and Heathcote Rivers adequately supported brown trout but urban stream beds provided poor habitats for many aquatic invertebrates since several parts of both rivers were heavily silted. Furthermore, TSS measurements at these locations were low in the present study. According to EOS Ecology et al. (2011) and J. Harding and Jellyman (2015), the earthquake caused an increase in depth of silt and sand in waterways throughout the city as well as many parts of the Avon River. It was presumed that cobbles in the river bottom might have been smothered by accumulated sediment. The decline in invertebrate taxonomic richness, fish richness and density were substantial. EPT taxa (Ephemeroptera, Plecoptera and Trichoptera) and fish disappeared from some heavily silted streams. In addition, a rise in tolerant taxa such as snails were observed within the upper wadeable river.

At the Botanic Gardens, high levels of BOD, NNN and DRP were observed. High levels of nutrients were common problems of water quality in most study locations. Excessive

concentrations of BOD_5 might have attributed to broken infrastructure such as sewage pipes leaking sewage into the river (Rutherford & Hudson, 2011). High BOD_5 resulted in decreased dissolved oxygen and there was the potential for an impact on fish and other aquatic life. According to Bartram (2014a), the water quality of the Avon River is influenced by the water quality of their origins, the stormwater quality running from the land during rainfall and the water quality of the Estuary impacting the lower tidal reaches. Nitrogen concentrations were high at locations at the origin of the Avon River because the levels of nitrate were high in the groundwater in the shallow aquifers in the Christchurch-West Melton area. In the present study, the high levels of DRP at the Botanic Gardens may have been the result of a few Avon River tributaries upstream of the study location. The Avon River tributaries generally presented greater levels of DRP than the main stream (Margetts, 2014).

In summer, there were occasions when turbidity results at all river locations exceeded the trigger value. This was most likely due to the removal of aquatic plants by the CCC upstream at the Botanic Gardens towards as well as high levels of participation in water-based activities at the Botanic Gardens and Antigua Boatsheds (kayaking, punting and canoeing) (Photo 14 Appendix 8).

The water at the Botanic Gardens and Antigua Boatsheds might have posed health risks to recreational users since *E.coli* levels occasionally exceeded the alert and trigger values. Environment Canterbury monitored *E.coli* levels at a location in the Avon River central city located within the resource evaluation at Antigua Boatsheds. The data were only collected from 2000 - 2005, and the location was graded as “very poor” making it unsuitable for contact recreation (Environment Canterbury, 2015). The present increase in *E.coli* concentrations at these locations may have been the result of disturbance of

water by high participation in boating, rainfall that usually carried dog faeces and sewage overflows or leakage from damaged sewerage pipes into the river. This was consistent with Moriarty et al. (2013) who found that the disturbance of the sediment could remobilize microorganisms in the water column. Disturbance events could potentially escalate human health risks for those who participated in recreational activities in the river and the Estuary. Added to this was the numerous and regular presence of waterfowl at the Botanic Gardens and Antigua Boatsheds. These birds were likely to be a significant source of faecal contamination of river water.

More facilities were available for public use at the Botanic Gardens compared to all other locations even though the earthquake impacted a few facilities at this location. Most of these facilities were in good condition, usable and attractive so they adequately supported numerous recreational users. Although the Antigua Boatsheds had fewer facilities and more surrounding buildings compared with the Botanic Gardens, the "Watermark" area featured new pathways, boardwalks and landscaping that appealed to recreationists. This could enhance the river to a similar value as the Botanic Gardens. Buildings, distinctive bridges and other man made creations prominently contributed to the public's aesthetic appreciation of the riverscape (Gobster & Westphal, 2004). In the present study, recreationists at Antugua Boatsheds could enjoy beautiful river views from the bridges and value the peace and solitude of getting close to the river edge from the boardwalks (Photo 15 Appendix 8). According to Gobster and Westphal (2004), the experience of river views, the quietness and peacefulness of being down by the river edge and the presence of river were an aesthetic in nature that contrasted with the urban fabric. To those living in urban areas, visual access to scenery like the river often provided a visual break. Busy urban lives are replenished by experiencing nature and

aesthetically pleasing phenomena. These were values for inspiration, creativity and the creation of more beauty.

Contrasting with the above locations, at Kerrs Reach had few green attributes. There was excessive growth of plants, weed and algae as well as animal faeces which may have resulted in a deterioration of the ecosystem health and which was also unattractive to recreational users. Furthermore, along the river many houses were being demolished and rubbish had accumulated due to there being insufficient trash bins available. All of these might have reduced the attractiveness of the location and the users' enjoyment of activities on the Avon River. Gobster and Westphal (2004) reported that the experience of the river was appreciated due to the presence of wildlife, but cleanliness of the river and its surrounding was of the most concern of Chicago River stakeholders.

Similar to the Antigua Boatsheds, Kerrs Reach provided poor habitats for invertebrates. The water quality was severely polluted (as indicated by MCI scores of around 61) and the riverbed was heavily silted. Freshwater invertebrates found at the location included many tolerant taxa. Kerrs Reach also faced similar problems to the Botanic Gardens with high concentrations of BOD_5, NNN and DRP. According to Bartram (2014a), high concentrations of DRP at downstream locations were increasingly caused by urban land use and stormwater. Reduced NNN levels downstream have been attributed to uptake by plants and algae as the river flows through urban Christchurch. The concentrations of NNN are also diluted by water from other inputs such as tributaries and stormwater. These excessive levels of nutrients potentially result in disproportionate growth of aquatic plants and algae in the Avon River. However, adequate phosphorus, light and temperature are needed for growth (Bartram, 2014a). Thus, this might have reflected a

case of continuing problems of weed growth at Kerrs Reach since the location lacked vegetation shading and had high concentrations of nutrients.

A weed-cutter boat was occasionally used to eliminate weed growth at Kerrs Reach and other lower parts of the river, but this problem was still persistent. This was because high nutrient levels were affected by land use in the catchment (Environment Canterbury, 2012). Hence, any remedy to this problem would require a long term solution. For a short term solution, it was suggested that more work might be done to remove pond-weed, remove rubbish from the river and its banks, accommodate more trash bins and prevent waterfowl from defecating on the pontoons. Also, the removal of weed might disperse waterfowl to some other parts of the river. All of these options can promote cleanliness and aesthetic in nature of the location that will attract more recreationists in the future. These two attributes were valued human dimensions important for recreation experiences (Gobster & Westphal, 2004).

Kerrs Reach was a location of critical concern of water quality for contact recreation since it has been home for rowing and kayaking of Christchurch. The present finding indicated that *E.coli* measurements were high on a few occasions. Historical investigations classify the water quality at Kerrs Reach as “very poor” making the location unsuitable for contact recreation (Environment Canterbury, 2015). This continuing issue is unlikely to change in the near future due to the diversity of waterfowl in the river (Bolton-Ritchie, 2014). In the present study, it was found that the location lacked a riparian zone along the river. This allowed waterfowl and dog faecal matter on the river banks being directly washed down into the river during rainfall events.

As a consequence of earthquake disturbances, facilities on the shores and tracks along the banks of the river for walking and cycling had a lot of damage (Sport Canterbury,

2011). The present research found that the tracks and shore facilities have been improved for rowing, kayaking, walking, running and cycling. As the roads along the river were damaged, access to some locations was restricted. Despite poor water quality, rowing and kayaking activities continued. Infrastructural facilities and amenities can substantially influence the recreational values of urban areas as well (Voigt et al., 2014). Therefore, at Kerrs Reach new facilities should be made to support not only water-based activities but also relaxing activities. For instance, the provision of picnic tables or benches would facilitate those people who enjoy viewing boating activities on the river and encourage participation in recreation at this location.

Regarding the future, Kerrs Reach on the Avon River is being considered for an Avon sport and regional hub (immediate, 1-3 year plans) as it has been the traditional home for flat water sports in greater Christchurch. An area adjacent to the river is widely utilized for recreation including walking, cycling and running. There is potential for developing a world class hub for a broad variety of sports and recreation activity at Kerrs Reach. This would involve water sports such as rowing, kayaking, waka ama and dragon boating and land based activities such as road cycling, mountain biking, BMX and other recreational activities. This hub would foster day by day use as well as hosting local, regional and national events such as BMX, cycling and across county running (Sport and Recreation Earthquake Leadership Group, 2013).

The earthquake was detrimental to the resources at Pleasant Point Jetty but those remaining could still facilitate some recreational activities at the location. The jetty's natural settings including grass, picnic areas, pine trees and the water provided values for some activities such as (dog) walking, enjoying scenery, fishing, kayaking and yachting. Marine invertebrates dominated the mudflat which also had birds present. According to

McMurtrie and Kennedy (2012), Pleasant Point Jetty is the common low tide feeding ground. In recent years, the practice of releasing treated sewage directly into the Estuary has stopped and the health and value of the Estuary as a wildlife and recreational reserve has been enhanced. A wildlife refuge has been established at the wastewater treatment ponds while wetlands have been created in Charlesworth and Bexley Wetland (McMurtrie & Kennedy, 2012). Natural environment, trees, wildlife and other natural-related attributes have improved the enjoyment and utilization of recreational areas (Gobster & Westphal, 2004). In the present study, some birds found at the location still offered opportunities for the appreciation of watching birds at low tide. In summer, the presence of abundant seaweeds on top of the high tide zone degraded the aesthetic value of the location but the scenic beauty out to the hills was retained.

The water quality at Pleasant Point Jetty had greater concentrations of NH_3N, DRP, TSS and turbidity than all the other locations. High turbidity measurements were likely to have been caused by high flows and tidal movement as well as strong, wind suspended fine sediment particles in the water column on those particular sampling days. Greater concentrations of NH_3N, DRP, TSS and turbidity at downstream locations were increasingly impacted by urban land use and stormwater (Bartram, 2014a). The water quality within the Estuary was impacted by the water quality of the Avon and Heathcote Rivers but the former is the main contributor. Substantial amounts of NNN and TSS at the Estuary received from both rivers, especially the Heathcote River (Bartram, 2014b). In addition, the temperature at Pleasant Point Jetty elevated to 21.5°C on the last sampling round in summer. For contact recreation, both *E.coli* and *Enterococci* measurements were low. However, recreational water quality at this location was not graded due to insufficient data (Environment Canterbury, 2015).

Facilities available at Pleasant Point Jetty were limited and in poor condition due to the the earthquake. A number of facilities and infrastructure remained broken and unrepaired. Remaining pine trees might have caused a danger to recreationists. Also, the earthquake resulted in the subsidence of the northern area of the estuary and has made the shore vulnerable to flooding (Environment Canterbury, 2011). These existing problems have become a hindrance for recreational uses of this location. Properties with poor maintenance and decreased safety lessen and prevent the use of recreation areas (Bixler & Floyd, 1997; Burgess et al., 1998; Gobster, 2002; McCormack et al., 2010; Schroeder & Anderson, 1984). Before the earthquake, South New Brighton Park, South New Brighton walkway and the jetty were highly valued for community recreation, leisure and well-being (Crawford & Fountain, 2010). People enjoyed a wide range of activities such as playing with children, sitting and relaxing in the shade, digging in the sand for shells, watching birds from the jetty, photographing birds and experiencing peacefulness. Peacefulness and solitude often play an important part in the experience of the nature (Gobster & Westphal, 2004). Furthermore, McCormack et al. (2010) showed that besides proximity, safety, maintenance and aesthetics, specific facilities are crucial for physical activities (playgrounds, sport courts, tracks). In the present study, the playground and sport court were occupied much of the time during the resource evaluation. Most of the pre-earthquake activities still took place at Pleasant Point Jetty even though the levels of participation declined and facilities were primitive. Recreationists still value those activities and mainly rely on the resources they have in the community.

In order to guide the recovery and development of reserves, the South New Brighton Reserve Development Plan was proposed (Christchurch City Council, 2014b). Environmental, cultural, economic, recreational and landscape attributes were taken into consideration. A concept plan for South New Brighton Park was also included in the

development plan. Development of the park involves replacing or repairing existing toilets, jetty, boat ramps; replanting stone pines, native coastal forests and creating exotic woodland areas. Additional areas for development are constructing stop banks and shared tracks on the stop banks, a new bike pump track and picnic areas around the river and the Estuary margin; redeveloping car parks and investigating yachting facilities. The plan for 2014/2015 includes playground upgrade in which some facilities will be retained and new facilities will be established. The upgrade will also represent cultural values of tangata whenua and the wider community history.

Recreational resources at Moncks Bay offer recreationists the opportunity to enjoy several activities although there were fewer trees, vegetation and facilities available compared to most locations. For example, Kerrs Reach had more trees and other green attributes but the lack of cleanliness, scenic beauty and aesthetic in nature have deteriorated the recreational values of that location. Meanwhile, the natural settings of Moncks Bay have provided recreationists with beautiful scenery, aesthetic in nature, cleanliness, the experience of wildlife and several water-based activities. All of these have contributed to the appreciation of activities at the location. For instance, those who walk along the Estuary Walk can also view the Spit and the Estuary mouth, birds and people participating in sailing.

The species diversity of intertidal animals was less at Pleasant Point Jetty than at Moncks Bay where there were species such as mussels, oysters, tube worms, pipi and cockles. There was foam floating on the water on a few occasions which might have reduced the appreciation of the water. But the water quality of this location did not present high concentrations of key contaminants of concern in Christchurch. There was a spike in DRP levels detected at this location on one occasion but it was below the trigger value.

Additionally, the measurements of salinity at Moncks Bay and Pleasant Point Jetty were inconsistent with the previous pattern. For example, the maximum levels of salinity at these locations was higher than the maximum values of 29.1 ppt at Pleasant Point Jetty and 34.4 ppt at Shag Rock as measured at high tide in 2013 (Bartram, 2014b). According to Bartram (2014b), the salinity within the Estuary at high tide is the consequence of the mixing of freshwater from the Avon and Heathcote Rivers with the incoming sea water. The effect on salinity is also associated with the quantity of freshwater entering the Estuary. The wind and tide impact on the mixing of freshwater with sea water.

Bacterial levels (*Enterococci* measurements) at this location were below the detection limit. According to Environment Canterbury (2015), the water quality at Moncks Bay was graded as "good" making the water at this location suitable for contact recreation most of the time. However, it was suggested that recreationists must avoid contact with the water after rainfall. The present research found that a health warning sign permanently erected at this location was not up to date.

The Christchurch Yacht Club building and facilities facilitate water-based activities, especially sailing. Seating areas close to the building and along the Estuary are beneficial for relaxation. More people preferred to fish from the fringe of the car park rather than other parts along the shore. In summer, the car park was mostly occupied when yachts were being launched on weekends. This might have restricted the use of the location to other recreational users. Furthermore, some parts of the Estuary Walk were narrow and a section of fence was missing alongside the walkway making it unsafe for recreationists. Safety is another prominent dimension in the urban green space (Gobster & Westphal, 2004). It was recommended by recreationists that toilets and hot showers should be constructed at this location since water-based activities were the key values of recreation

at the location. This would also support other recreational users. In order to facilitate bird watching, installing binoculars at the bird watching house might enhance the experience. Some recreationists believed that growing native plants along the Estuary Walk will increase natural appeal of the location and make an enjoyable estuary experience for users.

In order to provide recreational users with satisfactory experiences of the Avon River and the Estuary, it is essential to consider the requirements of local community. This should be a priority because the community is a main user of the river and the Estuary. It is important that the design of public recreational areas integrates multifunctional features to support various active and passive recreational activities (Maruani & Amit-Cohen, 2007; Voigt et al., 2014; Wolf & Appel-Kummer, 2009). However, it is inevitable that the improvement and management of these recreational areas will be challenging with respect to users' differing needs and gaining access to funding.

In summary, resources in the five recreational areas in Christchurch have continued to serve residents with a variety of activities even though the resources have been impacted by earthquake activity. The water quality of the Avon River and the Estuary had been degraded, especially the water at river locations was found unsuitable for contact recreation. Despite the drawbacks, waterways their surroundings, infrastructure and facilities still play an important part in the recreational attributes of urban areas. However, the improvement of water quality to support ecosystem health and recreation should be emphasized since Christchurch residents highly value the river and the Estuary for their recreation.

Chapter 5

Discussion and Research Implications

The Avon River and the Avon-Heathcote Estuary/Ihutai have retained diverse recreational opportunities for Christchurch inhabitants after the February 22nd earthquake in 2011. This research evaluated the current recreational opportunities using a questionnaire, assessed levels of public participation in recreational activities in winter 2014 and summer 2014-2015 and evaluated the quality of recreational resources in the river and the Estuary. Onsite questionnaires were used to gather information from different groups of recreational users. Questionnaires generated a high response rate. Adding electronic questionnaires supplemented the information from recreational users who participated in water-based activities. An instrument adjusted from SOPARC was successfully utilized to compare levels of public participation in recreation in winter and summer. The assessment of recreational resources at each study location (water quality, ecosystem health, facilities and infrastructure) provided information for a deeper investigation of post-quake recreational opportunities of the river and the Estuary.

Christchurch residents greatly value the river and the Estuary as locations for recreational pursuits. A wide range of activities have been undertaken, both in the past and the present. They include punting, kayaking, canoeing, rowing, sailing, standup paddle boarding, fishing, collecting shellfish, watching/feeding birds and ducks, (dog) walking, running, biking, sitting, playing with children, picnicking and viewing the environment. These activities have not only promoted cultural importance, the identity and character of the city, but they have also contributed to social relationships and family inclusion that can improve the quality of urban life.

After the February 22nd earthquake, some activity patterns around the river and Estuary have remained. Recreational areas in close proximity to residential places were most often used by recreationists. This fact was also highlighted in past studies (Crawford & Fountain, 2010; Greenaway, 2007; Marquet & Duncan, 2012; McKenna, 1979). Proximity is one of key contributors to participation rates of recreational areas (Madsen, 2011). Questionnaire participants considered weather conditions, the availability of facilities or resources, water aesthetics and proximity as the main factors for them making decisions about using the river and the Estuary for recreation. They mostly undertook activities throughout the year. However, for most recreational activities the levels of participation were greater in summer than in winter because summer weather conditions were considered more favourable. Nonetheless, location rather than season affected recreational levels. When considering the location, recreational value was related to the supply of recreational resources including facilities, infrastructure, ecosystem health and services, features, amenities and values of the river and the Estuary. These elements were impacted by the earthquake. Consequently, the earthquake disturbed recreational activities of some recreationists who undertook activities before the earthquake. The reduction of activities was attributed to the closure of the estuary, polluted water, inaccessible areas and construction along the river and roads.

The levels of participation post earthquake inevitably declined at a few locations but participation in activities generally remains high. This was because the majority of activities have resumed at all study locations. People who carried out activities prior to the earthquake have mostly continued to use the river and the Estuary for recreation. This is because residents have a strong attachment to local recreational areas and have a desire to be part of its restoration as a place of sport and recreation (T. Williams & Mackay,

2013). It was also found that participation rates of recreation at weekends were higher than weekdays.

Despite the continuing patterns of recreational activities, the impacts of the earthquake on features and values of recreational locations are still present. These impacts were found by those who recreated before the earthquake but also by current users of the river and the Estuary. Recreational opportunities were diminished by earthquake activity in 2011. An assessment of recreational resources at all study locations identified construction along the river, poor water quality, lack of footpaths and access to the river. Also, the water quality at all locations had deteriorated. There were bridge constructions at Antigua Boatsheds and on the Bridge Street Bridge near Pleasant Point Jetty. This construction occasionally hampered access to these locations and resulted in uneven or broken tracks as seen at Pleasant Point Jetty.

The perceptions of those participating in the questionnaire had perceptions of water quality that appeared to contradict the results of resource evaluation. Most participants assessed the water quality as reasonable to good at present. However, the measurements of water quality indicated that most study locations had a degraded quality of water. High concentrations of nutrients occurred at all locations and high levels of *E.coli* were detected on a few occasions. River locations had probably moderate to probably severe pollution water and were unsuitable for contact recreation. The present study notes that the initial perception of a river mainly derived from the aesthetic appearance of the landscape (including water and its surroundings) (House et al., 1994; House & Sangster, 1991). For example, people usually use water clarity to judge water quality (Canter et al., 1992; Smith et al., 1992). Hence, in the present study the water quality perceptions of participants might have been influenced by water appearance. However, the water at

Kerrs Reach was perceived as poor by most participants undertaking activities at this location. This was consistent with the scientific assessment of water quality. Some factors impacting public perception of water quality are personal usage of water and familiarity of contaminants and sources (Canter et al., 1992). Most participants at Kerrs Reach were those who have frequently been made aware of ongoing problems of the location such as excessive growth of aquatic plants and algae, silt accumulation, sewerage discharge from upstream, high levels of faecal contamination and abundant amount of waterfowl. Some of these problems also distracted aesthetic appeal of the water at this location.

In terms of ecosystem health, river locations provided unsuitable habitats for sensitive invertebrates but some fish and eels were seen. It was found that river users valued the aesthetic attractiveness and the ecological health of the river. However, the aesthetic value of the river environment was rated higher than the ecosystem health (Dodson, 2007). All study locations other than Kerrs Reach presented a moderate to high number of amenities and aesthetic appeal to recreationists. This has enhanced the utilization of recreation of the river and the Estuary. This present study did not conclude that recreational users of the river and the Estuary were unconcerned by water quality. Questionnaire participants mainly expressed concerns about the impact of water on the health of humans and animals. Other causes of concern were associated with the impact of effluent, nutrients, stormwater runoff, chemicals, leakage of sewage, damaged pipes and construction particles appearing in the water. The effect of water quality on ecological health was of concern to a small number of participants only.

Participants' perceptions of water quality differed from the results of actual water analysis. However, most participants remained aware of bacterial pollution in the river

and the Estuary. The main sources of pollutants identified by participants were bacteria, sewage, stormwater run-off, overflows of drains, silt, animal faeces and wastewater from industries. Participants were unaware of the disturbance of sediments that was found to be another main cause of an accretion of *E.coli* levels in the water column. While participants perceived the health risks as low, there was potentially an increased health risk associated with the disturbance of sediments by boating activities. This type of disturbance was likely to occur more frequently than rainfall events, particularly at the Botanic Gardens and Antigua Boatsheds where some parts of the river are wadeable and shallow.

More than one source of information was utilized by questionnaire participants in order to make their decisions about using the river or the Estuary for recreation. Most participants decided based on their own evaluation while others included information from regional council, friends, newspapers, signs, CCC warnings, radio and local knowledge. It was suggested that an increase in *E.coli* levels due to the disturbance of sediments should be highlighted in information sources such as regional council, newspapers, signs, CCC warnings and radio. Furthermore, it was found that the health warning sign at Moncks Bay was not up to date. This aspect was also noted by Patrap (2011). However, participants in the present study largely followed the information and health warnings about bacterial pollution.

Other issues were also identified as factors affecting recreational resources at some locations. These issues included the lack of public toilets, picnic tables, benches, bike parking facilities and rubbish bins; unusable, broken and poorly maintained facilities and infrastructure; and the presence of animal faeces and rubbish. Most suggestions made by questionnaire participants for future improvement of facilities and infrastructure were

related to these issues. Maintenance conditions, aesthetics, safety and proximity are crucial for promoting the utilization of recreational areas (Cohen et al., 2010; Giles-Corti et al., 2005; Kaczynski et al., 2008; Loukaitou-Sideris, 1995; McCormack et al., 2010). Additionally, the recreational values of urban areas can be affected by infrastructural facilities and amenities (Voigt et al., 2014).

For the future development of recreational facilities, it is vital to consider the desires and needs of the main users of the river and the Estuary, especially Christchurch inhabitants and the local community. However, challenges facing the management of urban recreational areas included localized spaces available; high demands and utilization of green spaces; diverse demands, desires and activities (Voigt et al., 2014). The demand for outdoor recreation areas has already outweighed the supply (Clawson, 1959 as cited in Sessoms, 1963). Sport Canterbury (2011) highlighted that greater Christchurch is facing challenges that influence sport and recreation. These include the assessment of places, spaces and settlement processes with insurers as well as scarcity of resources and over-subscription of available funds. Most participants recommended improvements in facilities, infrastructure and activities. Current improvements of recreational resources at some locations and other proposed developments appear to satisfy some requirements mentioned by participants.

In terms of mental recovery from the earthquake, it could take 10 years for Christchurch residents to overcome post quake stress (McCrone, 2015). Nevertheless, access to new and repaired recreational, cultural and leisure facilities is a positive influence on quality of life and sense of community after the earthquake (Canterbury Earthquake Recovery Authority, 2014). Stress reduction may be attributed to nature experience, social activities, relaxation and restorative opportunities (Voigt et al., 2014). The importance of

nature is increasingly recognised as a contributor in improving physical and psychological health and well-being of people (Kaplan, 2001; Kuo, 2001; Ulrich, 1984; Wells, 2000).

The passion of many Christchurch residents is associated with the Garden City providing open spaces for psychological and physical wellbeing (Vallance et al., 2005). People rely on clean water to live healthy lives and to prosper (Environment Canterbury, 2012). Non-polluted freshwater that is suitable for swimming and provides habitats for abundant aquatic life is what New Zealanders desire for the future. Also, protection for most important rivers should be initiated, and environmental protection should not be traded off for the growth of the economy (Swaffield & Kerr, 2014).

There were limitations in the present research because relatively few sites were investigated. Also, seasonal patterns of recreation in the river and the Estuary have not been studied in detail. On the other hand, this research will facilitate recreational planning in the Avon River and the Estuary. A vision of the Avon-Heathcote Estuary Ihutai Trust is to create and maintain clean water, open space, safe recreation and healthy ecosystems (McMurtrie & Kennedy, 2012). Avon-Ōtākaro Network (AvON) has a vision to alter Christchurch's Avon River red zone to a land of a beautiful parks and reserves (Avon-Ōtākaro Network, 2014). Thus, understanding recreational uses, recognising current and future requirements and knowing the issues facing recreational users will provide useful information for promoting these visions. Also, this research will be useful for future studies undertaken in other countries including Laos. The management of water and recreation can be applied to planning design and the operation of projects and facilities. This research has provided knowledge on the governance and

institutional frameworks underpinning water resource management. The significance of safe recreation in Laos will be enhanced if more recreation-related studies are conducted.

In conclusion, the Avon River and the Avon-Heathcote Estuary/Ihutai continue to provide a variety of recreational opportunities for users. Activities that were negatively affected by the earthquake have resumed, but opportunities might be localized in some places due to the lack of facilities and infrastructure. There were greater opportunities of recreation in summer when compared to winter. Recreational users of the river and the Estuary were concerned about the water quality and aware of bacterial pollution in the waterways. The local authorities need to include more information on health warnings and ensure that the warnings are kept up to date. This will raise awareness of different groups of river and estuary users on how to reduce health risks and enjoy safe recreation. Furthermore, some issues of recreational resources were identified for feasible improvement in order to facilitate different activities. Existing problems of the water quality need to be addressed to nurture healthy ecosystems of the river and the Estuary. A resource evaluation would be beneficial for future planning and management of recreational uses in greater Christchurch. Consequently, the Avon River and the Estuary will continue to provide their users with various recreational opportunities for future generations. Current and future development of the Avon River and the Estuary will contribute to better quality of life, well-being and psychological health of Christchurch residents while they are recovering from the earthquake impacts. Finally, future research might look at seasonal patterns of recreation in greater Christchurch. Additional research might be undertaken with respect to spaces, places, issues and opportunities for recreation in the Avon River red zone as well as other main attractive locations within the Avon-Heathcote Estuary.

Appendix 1 Map of activity recording sites and recreational resource evaluation areas.


Kerrs Reach
Activity Recording Sites
Recreational Resource Evaluation Area
193 m
2004
Imagery Date: 4/26/2012 43°31'00.87" S 172°40'53.68" E elev 5 m eye alt 840 m
Google earth


Pleasant Point Jetty
Activity Recording Sites
Recreational Resource Evaluation Area
199 m
2004
Imagery Date: 4/26/2012 43°31'47.74" S 172°43'56.46" E elev 0 m eye alt 864 m
Google earth


Moncks Bay
Activity Recording Sites
Recreational Resource Evaluation Area
Google earth
Imagery Date: 4/26/2012 43°33'56.02" S 172°44'37.44" E elev 0 m eye alt 843 m

Interviewee number: ……..….

Location: ……..… Weather: …..……

Date/Day: …….……... Time: …..…….

Appendix 2 A questionnaire

Post-quake recreational opportunities in the Avon River and the Avon-Heathcote Estuary/Ihutai

You are invited to participate in the project "Post-quake recreational opportunities in the Avon River and the Avon-Heathcote Estuary/Ihutai" by completing this questionnaire.

The aim of the project is to take a snapshot of the following:

- To evaluate recreational opportunities in the river and the Estuary.
- To determine the main factors influencing recreational uses and identify which recreational activities have been influenced most by the February 22nd earthquake.
- To identify future options for promoting recreational activities.

As a recreational user in the river and the Estuary over the age of 16 years, participation in this project will involve the completion of this questionnaire survey that should not take longer than 15-20 minutes.

You will not be asked to participate in any follow-up activity and no risks are envisaged from participating in this survey.

Participation is voluntary. You can access the results of this project in a master's thesis that will be available in approximately 2 year's time on the web of University of Canterbury. The results of this project might be published in academic journals. However, you can be assured of your anonymity – the identity of any participant cannot be known by the researchers and cannot be made public. This research has been funded by the NZAid Scholarship Program. The project has been reviewed and approved by the Waterways Centre for Freshwater Management, University of Canterbury and the University of Canterbury Human Ethics Committee Low Risk process.

This project is being carried out by:

Ms. Palamy Xayasenh
A master's student at Waterways Centre for Freshwater Management
Tel: 022 3035545 or email: pxa10@uclive.ac.nz

If you have any concern about your participation, please do not hesitate to contact her or:
Associate Professor Islay Diane Marsden,
School of Biological Sciences,
University of Canterbury.
Tel: 03 0642041 Ext 6041 or email: islay.marsden@canterbury.ac.nz

Thank you for your time.

Interviewee number: ……..….

Location: ……..… Weather: …..……

Date/Day: ……..……... Time: …..…….

Q 1: Please indicate whether you consent to the following:

I consent to participate in the project by completing the following questionnaire.
I consent to publication of the results of the project with the understanding that anonymity will be preserved.

1. ☐ Yes
2. ☐ No

Q 2: Gender:

1. ☐ Male
2. ☐ Female

Q 3: Age range:

1. ☐ 16-25
2. ☐ 26-40
3. ☐ 41-60
4. ☐ 61-80
5. ☐ 80+

Q 4: Are you a resident of Christchurch?

1. ☐ Yes
2. ☐ No, I am a domestic tourist
3. ☐ No, I am an overseas tourist

Q 5: With whom do you usually undertake recreational activities? (Tick the boxes where applicable)

1. ☐ By myself
2. ☐ Family members
3. ☐ Friends
4. ☐ Other (Please specify) ……..

Q 6: How far away from the Avon River or the Estuary do you live?

1. ☐ 500 meters (Continue on **Q 8**)
2. ☐ 1 km (Continue on **Q 8**)
3. ☐ 5 km (Continue on **Q 7**)
4. ☐ 10 km (Continue on **Q 7**)
5. ☐ greater than 10 km (Continue on **Q 7**)

Q 7: If the distance is greater than 1 km, how do you usually get to the river or the Estuary?

1. ☐ Walking
2. ☐ Cycling
3. ☐ By a car
4. ☐ By a bus
5. ☐ By a taxi
6. ☐ Other (Please specify) ……..

Q 8: Where do you undertake recreational activities within the river or the Estuary? e.g. Eastern, Northern, everywhere ……

Q 9: Is there a seasonal pattern to your recreational activities? If YES when? e.g. only in Summer, all seasons …….

Q 10: Which recreational activities do you participate in the river or the Estuary? and how often do you participate in those activities? (Tick the boxes where applicable)

1. ☐ Punting
2. ☐ Kayaking
3. ☐ Rowing
4. ☐ Wind surfing/kite surfing
5. ☐ Sailing
6. ☐ Fishing
7. ☐ Collecting shellfish
8. ☐ Watching birds
9. ☐ (dog) Walking/sightseeing
10. ☐ Running
11. ☐ Biking
12. ☐ Other (Please specify) ……..…

Interviewee number: ……..….

Location: ……..… Weather: …..……

Date/Day: ……..……... Time: …..…….

Frequency of recreation	**Recreational activities**											
	Punting	Kayaking	Rowing	Wind surfing/ kite surfing	Sailing	Fishing	Collecting shellfish	Watching birds	(dog)Walking /Sightseeing	Running	Biking	Other …… ……
1. Less than once a month												
2. Once a month												
3. 2-3 times a month												
4. Once a week												
5. 2-3 times a week												
6. Daily												

Q 11: One year before the February 22nd earthquake, did you participate in any recreational activities in the river or the Estuary?

1. ☐ Yes
2. ☐ No (Continue on **Q 13.a**)

If YES, which recreational activities did you participate and how often did you participate in those activities? (Tick the boxes where applicable)

1. ☐ Punting
2. ☐ Kayaking
3. ☐ Rowing
4. ☐ Wind surfing/kite surfing
5. ☐ Sailing
6. ☐ Fishing
7. ☐ Collecting shellfish
8. ☐ Watching birds
9. ☐ (dog) Walking/sightseeing
10. ☐ Running
11. ☐ Biking
12. ☐ Other (Please specify) ……..…

Frequency of recreation	**Recreational activities**											
	Punting	Kayaking	Rowing	Wind surfing/ kite surfing	Sailing	Fishing	Collecting shellfish	Watching birds	(dog)Walking /Sightseeing	Running	Biking	Other …… ……
1. Less than once a month												
2. Once a month												
3. 2-3 times a month												
4. Once a week												
5. 2-3 times a week												
6. Daily												

Q 12: Did the February 22nd earthquake interfere with your recreational activity(ies) in the river or the Estuary? If YES, in what ways?

1. ☐ Yes, ……...
   ……
2. ☐ No

Q 13.a: The earthquake activity during 2011 affected many recreational activities. Please tick if the following changes on your enjoyment of recreational activities are important to you. (Tick the boxes where applicable)

1. ☐ Lack of foot paths.
2. ☐ Poor water quality.
3. ☐ Changes to the river mudflat.
4. ☐ Access to the river.
5. ☐ Construction along the river.
6. ☐ Other factors (Please specify) ……..

Q 14: In your opinion, what word best described water quality in the river and the Estuary BEFORE the February 22nd earthquake, 3-6 months post earthquake and now? (Tick the boxes where applicable)

Description of water quality	**Time periods**		
	BEFORE the February 22nd earthquake	3-6 months post earthquake	Present
1. Excellent			
2. Very good			
3. Good			
4. Reasonable			
5. Poor			

Q 15: Are you aware that urban rivers and estuaries have a high incidence of harmful bacteria and viruses entering nearby waterways?

1. ☐ Yes 2. ☐ No

Q 16: Are you concerned about water quality in the river and the Estuary? Please include why

1. ☐ Yes, …...……
2. ☐ No, ……
3. ☐ Sometimes, ……

Q 17: Do you know of any potential sources of bacteria pollution entering the river and the Estuary?

1. ☐ Yes 2. ☐ No

If YES, what pollution sources are you aware of?

……
……

Q 18: Now that the Estuary has reopened for recreation, in your opinion, at what level are the health risks of entering the water?

1. ☐ High
2. ☐ Medium
3. ☐ Low
4. ☐ Unsure

Q 19.a: Do you follow information and health warnings about bacterial pollution that might influence your decisions about using the river or the Estuary for recreation?

1. ☐ Yes (Continue **Q 20.a**)
2. ☐ No (Continue **Q 22.a**)

Q 20.a: If YES, on what source(s) of information is your opinion on the above question based? (Tick the boxes where applicable)

1. ☐ Own evaluation
2. ☐ Reports from a recreation club
3. ☐ Friends
4. ☐ Newspaper reports
5. ☐ Regional Council
6. ☐ Other (Please specify) …..

Q 22.a: If you have NOT followed the health warnings, please include why

……
……

Q 23.a: What factors other than information and health warnings about bacterial pollution might influence your decisions about using the river or the Estuary for recreation? (Tick the boxes where applicable)

1. ☐ Weather conditions
2. ☐ Water aesthetics (Appearance, smell, colour, clarity)
3. ☐ The availability of facilities or resources (Plants, wildlife)
4. ☐ Tides
5. ☐ Proximity
6. ☐ Costs of travel
7. ☐ Safety
8. ☐ Recommendations
9. ☐ Other (Please specify) ……..

Q 24: Do you think the resources available for recreational use of the river and the Estuary are improving or not? Please give reasons.

……
……
……
……
……

Q 25: If the Avon River and the Estuary will be developed for the hub of recreational activities, what kinds of recreational activities or events would you desire to see most? Please give reason.

……
……
……
……
……

Q 26: Are there any facilities or infrastructures for recreational uses that you would like to see developed in the future?

……
……
……
……
……

Q 27: Please make any other comments which may relate to this survey

……
……
……
……
……

Appendix 3 Contact letter to recreational groups

Contact Letter

TO WHOM IT MAY CONCERN

I am writing to request your assistance in encouraging your members to participate in the project **"Post-quake recreational opportunities in the Avon River and the Avon-Heathcote Estuary/Ihutai"** by filling out a questionnaire electronically.

The aim of the project is to take a snapshot of the following:

- To evaluate recreational opportunities in the river and the Estuary.
- To determine the main factors influencing recreational uses and identify which recreational activities have been influenced most by the February 22nd earthquake.
- To identify future options for promoting recreational activities.

It would be greatly appreciated if your organization could promote a survey, posting the questionnaire attached herewith, on your website and/or other general communications to your members. Once the questionnaire is filled out electronically, it should be sent back to the researcher by email on pxa10@uclive.ac.nz

As a recreational user in the river and the Estuary over the age of 16 years, participation in this project will involve the completion of this questionnaire survey that should not take longer than 15-20 minutes.

Participation in this project is voluntary. Participation can be withdrawn from the research including any information provided by not submitting the survey to the researcher. Please note that as identity is not recorded on the questionnaire, once you have submitted the your answers, we will not be able to withdraw your data. You will not be asked to participate in any follow-up to this investigation. In the performance of the tasks and application of the procedures, there are no risks envisaged from participating in this survey.

Participants can access the results of this project in a master's thesis that will be available in approximately 2 year's time on the web of University of Canterbury. The results of the project may be published, but you may be assured of the complete confidentiality of data gathered in this investigation. To ensure anonymity and confidentiality, any personally identifying information will not be used during the processing of data, nor in the final report. In the final report, participants will only be indentified using broad descriptors.

All collected information will be kept in a secure locked file in the primary investigator's supervisor's office for the duration of the research project. Agencies with research oversight such as the Human Ethics Committee have authority to review the research data.

Could you please contact Ms. Palamy Xayasenh, a master's student at Waterways Centre for Freshwater Management, by email on pxa10@uclive.ac.nz or by phoning 022 3035545 to advise her if you are willing and able to assist.

If you would like to discuss other aspects of the project, please do not hesitate to contact Associate Professor Islay Diane Marsden, School of Biological Sciences, University of Canterbury. Email: islay.marsden@canterbury.ac.nz or tel: 03 0642041 Ext 6041.

Yours sincerely,
Palamy Xayasenh
25th November 2014

Appendix 4 Information sheet and consent form for recreational users (electronic)

Waterways Center for Freshwater Management
University of Canterbury
pxa10@uclive.ac.nz
15 Oct 2014

Information sheet and consent form for recreational users

You are invited to participate as a subject in the research entitled: **"Post-quake recreational opportunities in the Avon River and the Avon-Heathcote Estuary/Ihutai"**. The aims of this project are to evaluate recreational opportunities, to determine the main factors influencing recreational uses and to identify future options for promoting recreational activities in the Avon River and the Estuary.

Your involvement in this project will be filling out a questionnaire electronically that asks you to provide information on recreational uses, observed changes to the site and opportunities for developing recreational activities. Once the questionnaire is filled out electronically, it should be sent back to the researcher by email on pxa10@uclive.ac.nz. The questionnaire will consist of YES/NO and multiple choice questions. However, there will be several opportunities to expand upon your answers with an open-ended narrative response. Completion of the survey will take approximately 15-20 minutes.

Participation in this project is voluntary. Participation can be withdrawn from the research including any information provided by not submitting the survey to the researcher. Please note that as identity is not recorded on the questionnaire, once you have submitted the your answers, we will not be able to withdraw your data. You will not be asked to participate in any follow-up to this investigation. In the performance of the tasks and application of the procedures, there are no risks envisaged from participating in this survey.

You can access the results of this project in a master's thesis that will be available in approximately 2 year's time on the web of University of Canterbury. The results of the project may be published, but you may be assured of the complete confidentiality of data gathered in this investigation. To ensure anonymity and confidentiality, any personally identifying information will not be used during the processing of data, nor in the final report. In the final report, participants will only be indentified using broad descriptors.

All collected information will be kept in a secure locked file in the primary investigator's supervisor's office for the duration of the research project. Agencies with research oversight such as the Human Ethics Committee have authority to review the research data.

The project is being carried out as a requirement for a Master's Degree in Water Resource Management by Palamy Xayasenh under the supervision of Associate Professor Islay Diane Marsden (School of Biological Sciences, University of Canterbury), who can be contacted at islay.marsden@canterbury.ac.nz. She will be pleased to discuss any concerns you may have about participation in the project.

By participating in the study, it is understood that you have provided consent for the information to be used in the study because this is an anonymous questionnaire.

The project has been reviewed and approved by the Waterways Center for Freshwater Management, University of Canterbury and the University of Canterbury Human Ethics Committee Low Risk process, and participants should address any complaints to The Chair, UC Human Ethics Committee Low Risk process, University of Canterbury, Private Bag 4800, Christchurch or human-ethics@canterbury.ac.nz.

Regards,
Palamy Xayasenh

Appendix 5 Chi-square tests for a questionnaire (Chapter 2)

	X^2 value	Df	Critical value	P
Testing if age groups of participants in both seasons are the same or not				
Age groups	1.1709	4	3.357	NS
Testing if travelling distances from residential places to recreational locations in both seasons are the same or not				
Botanic Gardens	0.6909	4	3.357	NS
Antigua Boatsheds	1.52	4	3.357	NS
Kerrs Reach	3.6874	3	2.366	P=0.5
Pleasant Point Jetty	3.6571	3	2.366	P=0.5
Moncks Bay	5.6317	4	3.357	P=0.5
Testing if participants' recreational activities in each location in both season are the same or not				
Botanic Gardens	19	5	4.351	P=0.5
Antigua Boatsheds	7.8071	4	3.357	P=0.5
Kerrs Reach	3.0568	3	2.366	P=0.5
Pleasant Point Jetty	4.4235	5	4.351	P=0.5
Moncks Bay	4.9613	8	7.3441	NS
Testing if frequency of recreational activities in both seasons are the same or not				
Kayaking	3.0384	4	3.357	NS
Fishing	2.8083	3	2.366	P=0.5
Watching birds	7.6561	5	4.351	P=0.5
(dog) Walking/sightseeing	4.3851	5	4.351	P=0.5
Running	3.1727	3	2.366	P=0.5
Biking	1.5902	5	4.351	NS
Other	5.1623	5	4.351	P=0.5
Testing if participants' recreational activities before and after the earthquake are the same or not				
All activities	4.7709	9	8.3428	NS
Testing if frequency of recreational activities before and after the earthquake are the same or not				
Kayaking	1.1915	4	3.357	NS
Rowing	1.8701	3	2.366	NS
Fishing	0.8329	4	3.357	NS
Watching birds	0.6751	5	4.351	NS
(dog) Walking/sightseeing	1.3733	5	4.351	NS
Running	0.617	4	3.357	NS
Biking	1.3468	5	4.351	NS
Other	2.2652	5	4.351	NS

Appendix 6 Chi-square tests for public participation in recreational activities

(Chapter 3)

	X^2 value	**Df**	**Critical value**	**P**
Testing if age groups of public recreationists in both seasons are the same or not				
Age groups	0.9318	3	2.366	NS
Testing if individual and group participation in both seasons are the same or not				
Type of participation	0.9502	1	0.455	P=0.5
Testing if male and female participation in both season are the same or not				
Gender	1.7432	1	0.455	P=0.5

Appendix 7 Recording sheet of recreational activities on the Avon River and the Avon-Heathcote Estuary/Ihutai

Recording sheet of recreational activities at the Avon River and the Avon-Heathcote Estuary/Ihutai

Location: …… **Spot:** …… **Date:** …… **Period:** …… **Starting time:** ……

Conditions of target area:

Accessible (e.g. not locked or rented to others) ☐ Yes ☐ No
Usable (e.g. is not excessively wet or windy) ☐ Yes ☐ No
Equipped (e.g. removable balls available) ☐ Yes ☐ No
Supervised (e.g. by official personnel) ☐ Yes ☐ No
Organized (e.g. team sporting events) ☐ Yes ☐ No

Dark (e.g. insufficiently lit) ☐ Yes ☐ No
Empty (e.g. area not occupied) ☐ Yes ☐ No

Comments:

Participants		Age group				Recreational activities											
		Child	Teen	Adult	Senior	Punting	Kayaking	Rowing	Wind surfing/Kite surfing	Sailing	Fishing	Collecting shellfish	Watching birds	(dog) Walking/ Sightseeing	Running	Biking	Other … ……
Individual	M																
	F																
Group	M																
	F																

Appendix 8 Photo supplement

Photo 1 Waterfowl faeces on floating pontoons at Kerrs Reach.

Photo 2 Footpath closed for construction at Antigua Boatsheds.

Photo 3 Canoeing and Kayaking at Antigua Boatsheds.

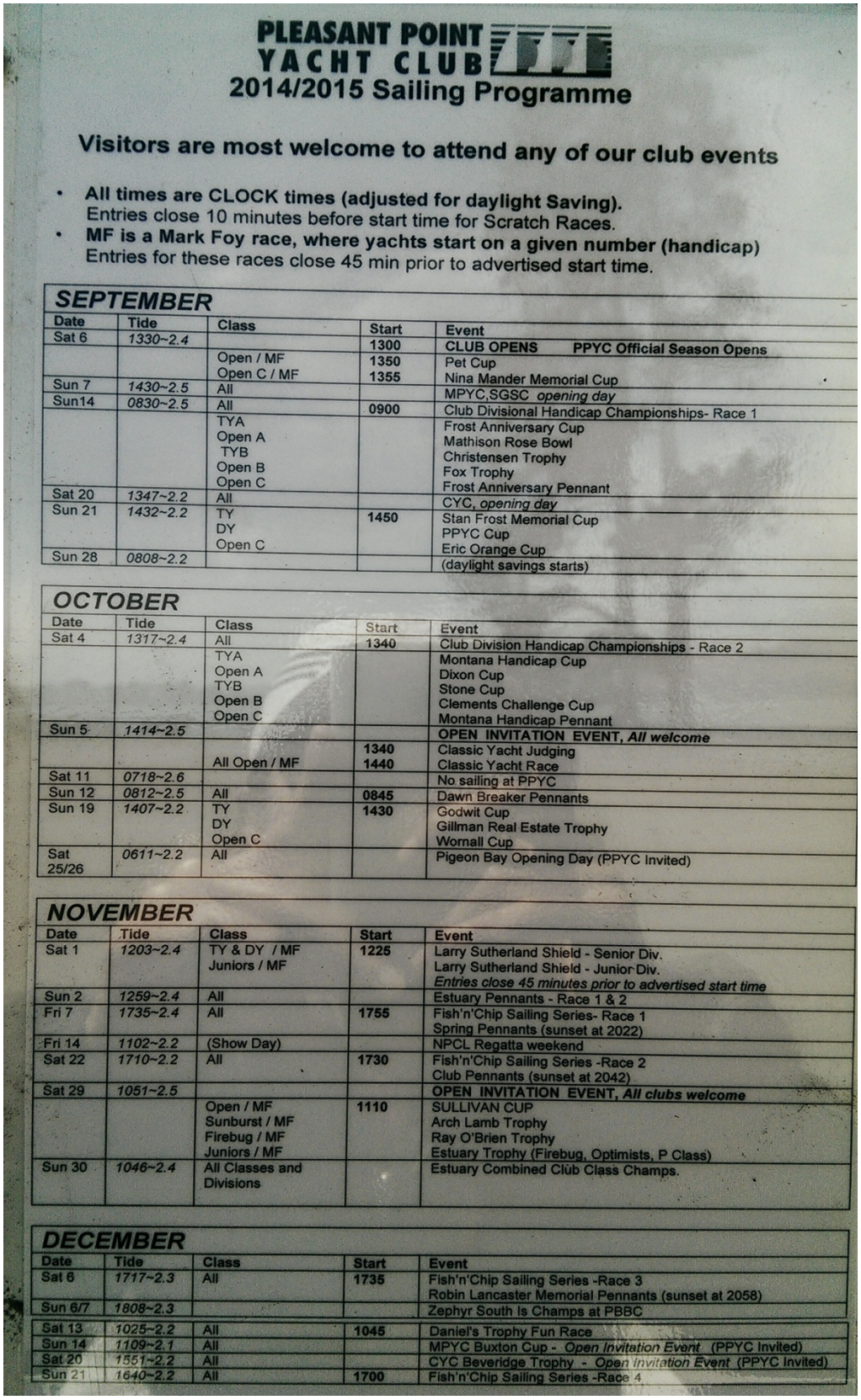
Photo 4 Guided punt tour from Antigua Boatsheds to the Botanic Gardens.

Photo 5 Christchurch Yacht Club Sailing at Moncks Bay.

Photo 6 Fishing at Moncks Bay.

Photo 7 Public continued to use the broken jetty at Pleasant Point Jetty.

Photo 8 Bank modification made from cement blocks at the Botanic Gardens.



PLEASANT POINT YACHT CLUB
2014/2015 Sailing Programme

Visitors are most welcome to attend any of our club events

- **All times are CLOCK times (adjusted for daylight Saving).**
  Entries close 10 minutes before start time for Scratch Races.
- **MF is a Mark Foy race, where yachts start on a given number (handicap)**
  Entries for these races close 45 min prior to advertised start time.

SEPTEMBER

Date	Tide	Class	Start	Event
Sat 6	*1330~2.4*		1300	**CLUB OPENS PPYC Official Season Opens**
		Open / MF	1350	Pet Cup
		Open C / MF	1355	Nina Mander Memorial Cup
Sun 7	*1430~2.5*	All		MPYC,SGSC *opening day*
Sun14	*0830~2.5*	All	0900	Club Divisional Handicap Championships- Race 1
		TYA Open A TYB Open B Open C		Frost Anniversary Cup Mathison Rose Bowl Christensen Trophy Fox Trophy Frost Anniversary Pennant
Sat 20	*1347~2.2*	All		CYC, *opening day*
Sun 21	*1432~2.2*	TY DY Open C	1450	Stan Frost Memorial Cup PPYC Cup Eric Orange Cup
Sun 28	*0808~2.2*			(daylight savings starts)

OCTOBER

Date	Tide	Class	Start	Event
Sat 4	*1317~2.4*	All	1340	Club Division Handicap Championships - Race 2
		TYA Open A TYB Open B Open C		Montana Handicap Cup Dixon Cup Stone Cup Clements Challenge Cup Montana Handicap Pennant
Sun 5	*1414~2.5*			**OPEN INVITATION EVENT, *All welcome***
		All Open / MF	1340 1440	Classic Yacht Judging Classic Yacht Race
Sat 11	*0718~2.6*			No sailing at PPYC
Sun 12	*0812~2.5*	All	0845	Dawn Breaker Pennants
Sun 19	*1407~2.2*	TY DY Open C	1430	Godwit Cup Gillman Real Estate Trophy Wornall Cup
Sat 25/26	*0611~2.2*	All		Pigeon Bay Opening Day (PPYC Invited)

NOVEMBER

Date	Tide	Class	Start	Event
Sat 1	*1203~2.4*	TY & DY / MF Juniors / MF	1225	Larry Sutherland Shield - Senior Div. Larry Sutherland Shield - Junior Div. *Entries close 45 minutes prior to advertised start time*
Sun 2	*1259~2.4*	All		Estuary Pennants - Race 1 & 2
Fri 7	*1735~2.4*	All	1755	Fish'n'Chip Sailing Series- Race 1 Spring Pennants (sunset at 2022)
Fri 14	*1102~2.2*	(Show Day)		NPCL Regatta weekend
Sat 22	*1710~2.2*	All	1730	Fish'n'Chip Sailing Series -Race 2 Club Pennants (sunset at 2042)
Sat 29	*1051~2.5*			**OPEN INVITATION EVENT, *All clubs welcome***
		Open / MF Sunburst / MF Firebug / MF Juniors / MF	1110	SULLIVAN CUP Arch Lamb Trophy Ray O'Brien Trophy Estuary Trophy (Firebug, Optimists, P Class)
Sun 30	*1046~2.4*	All Classes and Divisions		Estuary Combined Club Class Champs.

DECEMBER

Date	Tide	Class	Start	Event
Sat 6	*1717~2.3*	All	1735	Fish'n'Chip Sailing Series -Race 3 Robin Lancaster Memorial Pennants (sunset at 2058)
Sun 6/7	*1808~2.3*			Zephyr South Is Champs at PBBC
Sat 13	*1025~2.2*	All	1045	Daniel's Trophy Fun Race
Sun 14	*1109~2.1*	All		MPYC Buxton Cup - *Open Invitation Event* (PPYC Invited)
Sat 20	*1551~2.2*	All		CYC Beveridge Trophy - *Open Invitation Event* (PPYC Invited)
Sun 21	*1640~2.2*	All	1700	Fish'n'Chip Sailing Series -Race 4

Photo 9 Pleasant Point Yacht Club 2014/2015 Sailing Programme.

Photo 10 Grass waste floating in the Avon River at Kerrs Reach.

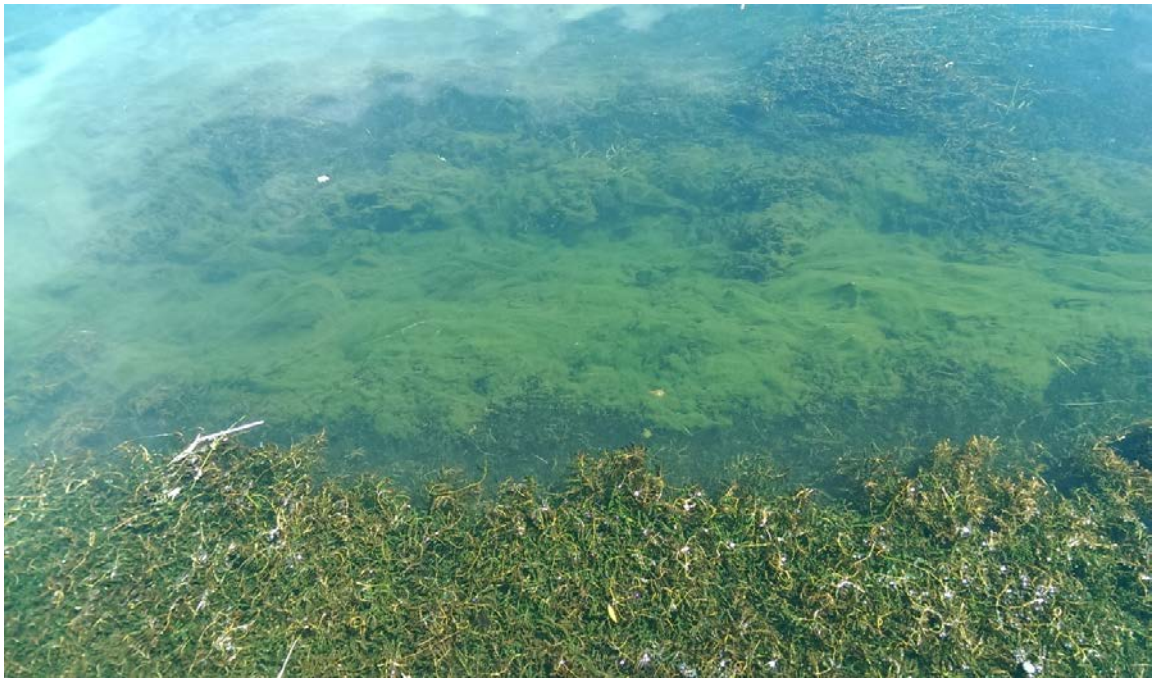


Photo 11 Excessive growth of aquatic plants and green algae along river margins at Kerrs Reach.

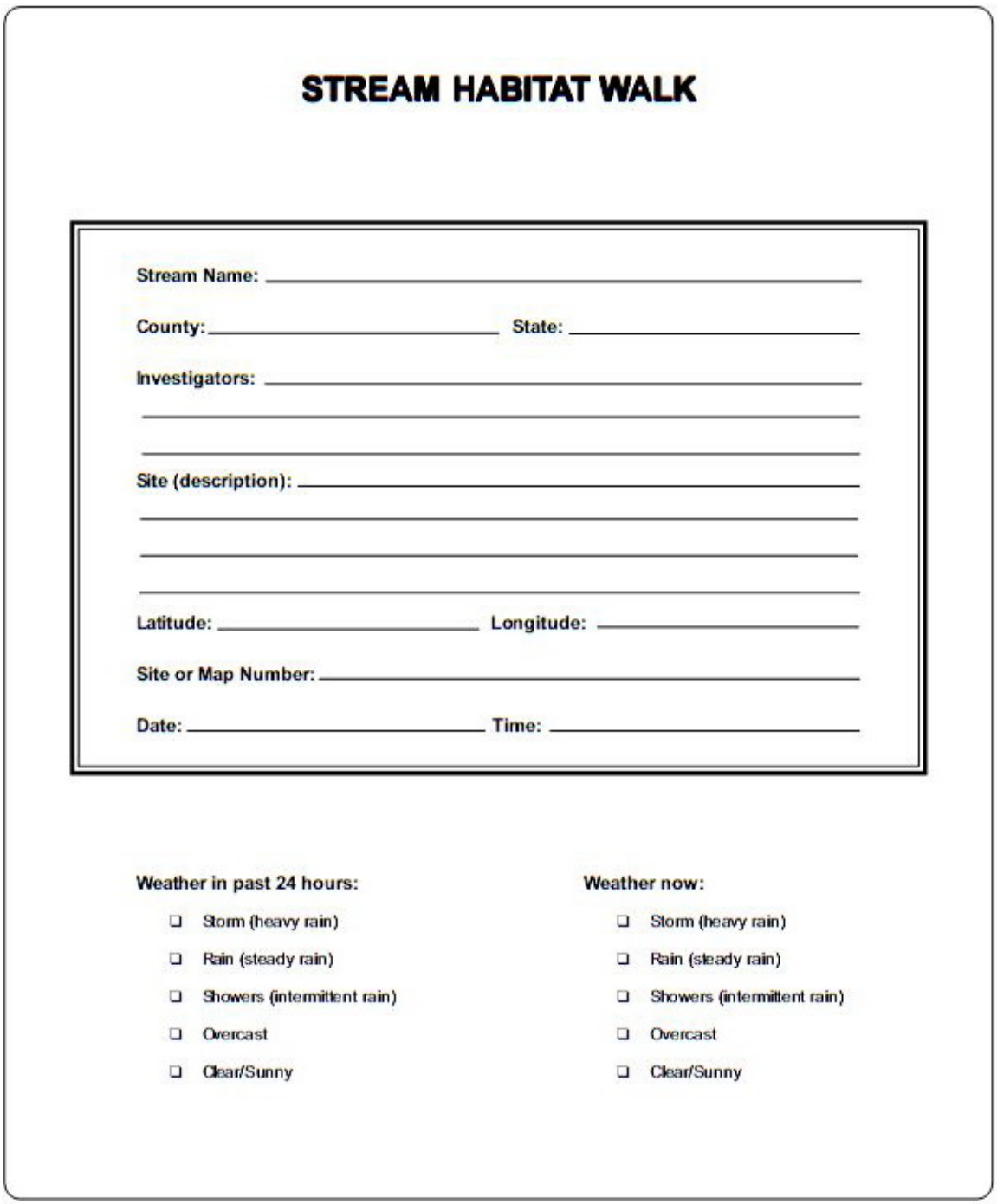
Photo 12 Green seaweeds dominated the top of hide tide zone in summer at Pleasant Point Jetty.

Photo 13 A wide range of red and brown algae on slipway at Moncks Bay.

Photo 14 Turbid water due to the removal aquatic plants at the Botanic Gardens.

Photo 15 Riverscape, boardwalks and seating areas at Antigua Boatsheds.

Appendix 9 Stream habitat walk



STREAM HABITAT WALK

Stream Name: _____

County: _____ State: _____

Investigators: _____

_____

_____

Site (description): _____

_____

_____

_____

Latitude: _____ Longitude: _____

Site or Map Number: _____

Date: _____ Time: _____

Weather in past 24 hours:

- ❑ Storm (heavy rain)
- ❑ Rain (steady rain)
- ❑ Showers (intermittent rain)
- ❑ Overcast
- ❑ Clear/Sunny

Weather now:

- ❑ Storm (heavy rain)
- ❑ Rain (steady rain)
- ❑ Showers (intermittent rain)
- ❑ Overcast
- ❑ Clear/Sunny

Sketch of site

On your sketch, note features that affect stream habitat, such as: riffles, runs, pools, ditches, wetlands, dams, riprap, outfalls, tributaries, landscape features, logging paths, vegetation, and roads.

PHYSICAL CHARACTERIZATION

In-Stream Characteristics

1. Check which stream habitats are present: Page 48

(You can check more than 1 habitat)

❑ Pool(s) θ Riffle(s) θ Run(s)

2. Nature of particles in the stream bottom at site Page 48

	None/Little	Some	Most
Silt/Clay/Mud	❑	❑	❑
Sand (up to 0.1" in diam.)	❑	❑	❑
Gravel (0.1 - 2" in diam.)	❑	❑	❑
Cobbles (2 - 10" in diam.)	❑	❑	❑
Boulders (over 10" in diam.)	❑	❑	❑
Bedrock (solid)	❑	❑	❑

3. Pick the category that best describes the extent to which gravel, cobbles, and boulders on the stream bottom are embedded (sunk) in silt, sand, or mud. Page 49

θ Somewhat/not embedded (0-25%) θ Mostly embedded (75%)

θ Halfway embedded (50%) θ Completely embedded (100%)

4. Presence of logs or large woody debris in stream: Page 49

θ None θ Occasional θ Plentiful

5. Presence of naturally-occurring organic material (i.e., leaves and twigs, etc.) in stream: Page 49

θ None θ Occasional θ Plentiful

6. Water appearance: Page 49

θ Clear θ Light brown θ Orange
θ Milky θ Dark brown θ Greenish
θ Foamy θ Oily sheen θ Other _____
θ Turbid

7. Water odor: Page 50

θ Sewage θ Fishy θ None
θ Chlorine θ Rotten eggs θ Other _____

8. Water temperature: Page 50

_____ °C *or* _____ °F

Streambank and Channel Characteristics

9. (a) Approximate depth of run(s): Page 50

θ < 1 ft θ 1-2 ft θ > 2 ft

(b) Approximate depth of pool(s):

θ < 1 ft θ 1-2 ft θ > 2 ft

10. Approximate width of stream channel: Page 50

_____ feet θ measured θ estimated

11. Stream velocity: _____ ft/sec. Page 50

12. Looking upstream (100 yds.), pick the description that best fits the shape of the stream bank and the channel. Page 50

(a) Stream bank:

Left		Right
θ	Vertical/undercut	θ
θ	Steeply sloping (> 30°)	θ
θ	Gradual/no slope (< 30°)	θ

(b) Extent of artificial bank modifications:

Left		Right
θ	Bank 0-25% covered	θ
θ	Bank 25-50% covered	θ
θ	Bank 50-75% covered	θ
θ	Bank 75-100% covered	θ

(c) Shape of the channel:

θ Narrow, deep θ Wide, deep
θ Narrow, shallow θ Wide, shallow

13. Looking upstream (100 yds.), describe the streamside cover. Check "1" if present, "2" if common Page 51

(a) Along water's edge and stream bank only:

Left			Right	
1	**2**		**1**	**2**
θ	θ	Trees	θ	θ
θ	θ	Bushes, shrubs	θ	θ
θ	θ	Tall grasses, ferns, etc.	θ	θ
θ	θ	Lawn	θ	θ
θ	θ	Boulders/rocks	θ	θ
θ	θ	Gravel/sand	θ	θ
θ	θ	Bare soil	θ	θ
θ	θ	Pavement, structures	θ	θ

(b) From the top of the streambank out to 25 yards.

Left 1	Left 2		Right 1	Right 2
θ	θ	Trees	θ	θ
θ	θ	Bushes, shrubs	θ	θ
θ	θ	Tall grasses, ferns, etc.	θ	θ
θ	θ	Lawn	θ	θ
θ	θ	Boulders/rocks	θ	θ
θ	θ	Gravel/sand	θ	θ
θ	θ	Bare soil	θ	θ
θ	θ	Pavement, structures	θ	θ

14. Pick the category that best describes the extent to which vegetation shades the stream at your site. Page 52

θ 0% θ 25% θ 50% θ 75% θ 100%

15. Looking upstream, note general conditions. Check "1" if present, "2" if severe problem is clearly Page 52

Left 1	Left 2	Stream Banks	Right 1	Right 2
θ	θ	Natural streamside plant cover degraded	θ	θ
θ	θ	Banks collapsed/eroded	θ	θ
θ	θ	Garbage/junk adjacent to the stream	θ	θ
θ	θ	Foam or sheen on bank	θ	θ
1	**2**	**Stream Channel**	**1**	**2**
θ	θ	Mud, silt, or sand in or entering the stream	θ	θ
θ	θ	Garbage/junk in the stream	θ	θ
1	**2**	**Other**	**1**	**2**
θ	θ	Yard waste on bank (grass, clippings, etc.)	θ	θ
θ	θ	Livestock in or with unrestricted access to stream	θ	θ
θ	θ	Actively discharging pipe(s)	θ	θ
θ	θ	Other pipe(s) entering the stream	θ	θ
θ	θ	Ditches entering the stream	θ	θ

Local Watershed Characteristics

(within about 1/4 mile of the site; adjacent and upstream)

16. Land uses in the local watershed can potentially have an impact on a stream. Check "1" if present, "2" if clearly having an impact on the stream. Page 53

1	2	
		Residential
θ	θ	Single-family housing
θ	θ	Multifamily housing
θ	θ	Lawns
θ	θ	Commercial/institutional
1	**2**	**Roads, etc.**
θ	θ	Paved roads or bridges
θ	θ	Unpaved roads
1	**2**	**Construction underway on:**
θ	θ	Housing development
θ	θ	Commercial development
θ	θ	Road bridge construction/repair
1	**2**	**Agricultural**
θ	θ	Grazing land
θ	θ	Feeding lots or animal holding areas
θ	θ	Cropland
θ	θ	Inactive agricultural land/fields
1	**2**	**Recreation**
θ	θ	Power boating
θ	θ	Golfing
θ	θ	Camping
θ	θ	Swimming/fishing/canoeing
θ	θ	Hiking/paths
1	**2**	**Other**
θ	θ	Mining or gravel pits
θ	θ	Logging
θ	θ	Industry
θ	θ	Oil and gas drilling
θ	θ	Trash dump
θ	θ	Landfills

BIOLOGICAL CHARACTERIZATION

VISUAL BIOLOGICAL SURVEY

17. Wildlife in or around the stream? *(Mark all that apply)* Page 53

θ Amphibians θ Waterfowl θ Reptiles θ Mammals

18. Fish in the stream? *(Mark all that apply)* Page 53

θ No θ Yes, but rare θ Yes, abundant

θ Small (1-2 in.) θ Medium (3-6 in.) θ Large (7 in. and above)

Are there any barriers to fish movement?

θ Beaver dams θ Waterfalls > 1' θ None

θ Dams θ Road barriers θ Other_____

19. Aquatic plants in the stream. *(Mark all that apply)* Page 53

θ None θ Occasional θ Plentiful

θ Attached θ Free-floating

θ Stream margin θ Pools θ Near riffle

20. Extent of algae in the stream. *(Mark all that apply)* Page 53

(a) Are the submerged stones, twigs, or other material in the stream coated with a layer of algal "slime"?

θ None θ Occasional θ Plentiful

θ Light coating θ Heavy coating

θ Brownish θ Greenish θ Other_____

(b) Are there any filamentous (string-like) algae?

θ None θ Occasional θ Plentiful

θ Brownish θ Greenish θ Other_____

(c) Are any detached "clumps" or "mats" of algae floating on the water's surface?

θ None θ Occasional θ Plentiful

θ Brownish θ Greenish θ Other_____

MACROINVERTEBRATE SURVEY *(Optional)*

21. If macroinvertebrates were collected from the stream bottom, which type of method/habitat was selected? Page 53

θ Rock-rubbing method: From cobbles and large stones selected from riffles.

θ Stick-picking method: From woody objects in streams with sandy, silty bottoms.

θ Leaf-pack sorting method: From submerged leaves in streams with either a rocky or sandy, silty bottom.

22. Are macroinvertebrates present? Page 54

θ No θ Yes, but rare θ Yes, abundant

23. If present, describe the types of macroinvertebrates found. Page 54

(Mark all that apply)

Wormlike	θ Occasional	θ Plentiful
Snails/clamlike	θ Occasional	θ Plentiful
Insects	θ Occasional	θ Plentiful
Crayfish	θ Occasional	θ Plentiful

COMMENTS: *(Note changes or potential problems such as spills, new construction, type of discharging pipes)*

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